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Hydro-Electric Development in Canadian Prairie Provinces

RAPIDLY INCREASING POPULATION IN AGRICULTURAL DISTRICTS OF THE DOMINION CALLS FOR POWER DEVELOPMENTS TO STIMULATE INDUSTRIAL GROWTH. BY F. C. PERKINS

ACCOMPANYING ILLUSTRATIONS Figs. 1 and 2 show the Kananaskis Dam and the Kananaskis Falls in Bow River and in photographs Figs. 3 and 4 and drawing Fig. 5 may be noted Bow River Horseshoe Falls and the Development of the Calgary Power Co. The Minnewanka Dam near Banff, Alberta, is shown in photograph Fig. 6 as another development of the water power of the Prairie provinces of Canada.

The writer is indebted to J. T. Johnston, Hydraulic Engineer of the Dominion Water Power Branch of Ottawa, Canada, for the accompanying illustrations and to Engineer Percival H. Mitchell, of Toronto, for the following valuable data on the water powers of prominence throughout the Prairie Provinces.

He points out that the Dominion of Canada has been most liberally endowed with a richness of natural resources possibly unrivalled in any country of the globe. The wealth of the land, the forest and the mine, has a world-wide reputation; the neighboring oceans, the lakes and the streams, for their transportation routes, their fisheries and their water powers are equally well known. The commerce and industry created by such a

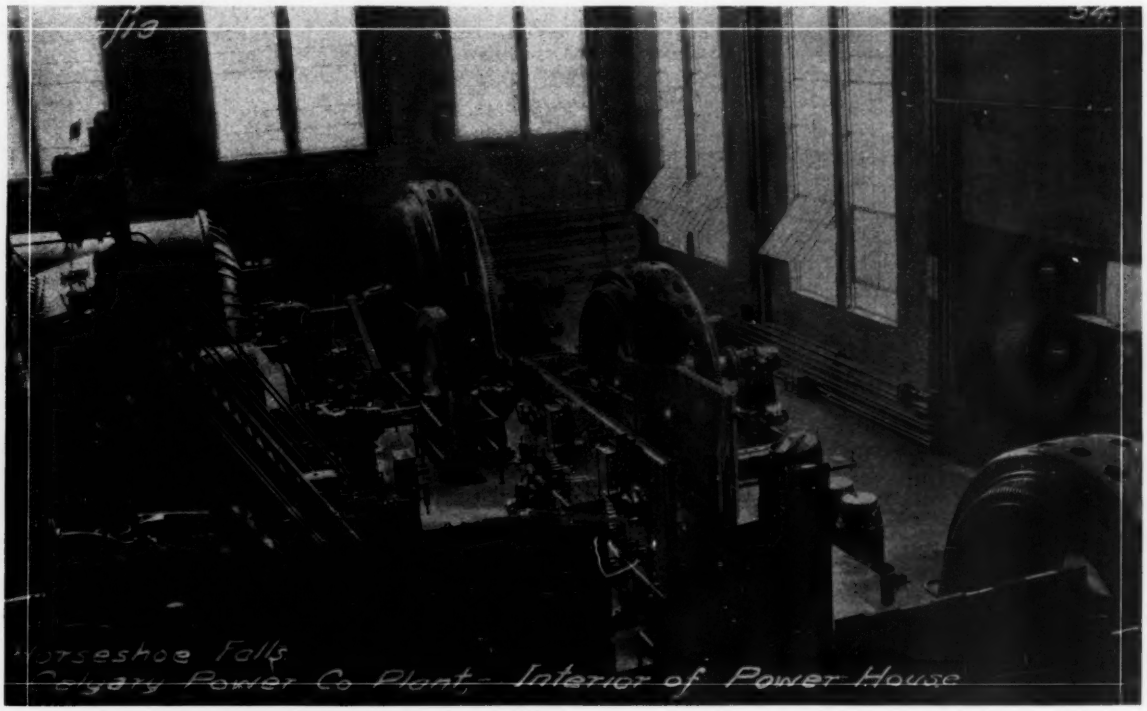


FIG. 4. INTERIOR OF HYDRO-ELECTRIC PLANT OF CALGARY POWER CO. AT HORSESHOE FALLS

fund of resources has as one of its greatest elements of success the proximity of water powers to the power consuming market.

The Eau Clair Plant was the first hydro-electric development on the Bow River, and was carried out by the Eau Clair Lumber Co., within the city limits of Calgary. While the initial type of construction used for development was not of the most permanent character, the possibilities are excellent for the construction of a very efficient plant at this point, utilizing the present head of 12 ft. The present capacity is 600 hp., which is used for lighting under a city franchise. This small plant is augmented by a steam plant and has thus become a reliable source of power.

FIG. 1. KANANASKIS DAM

Horseshoe Falls plant is located at Horseshoe Falls, about 50 mi. west of Calgary, and at this site is one of the few concentrated falls to be found upon the Bow River. The Bow River, at the Horseshoe Falls, in its natural state, flows through a deep gorge, the walls and bed of which are formed of a shale banded with sandstone. At this point a massive outcropping of inclined rock intervenes, and as time passed a channel was eroded through this natural dam and a fall of some 25 ft. occurred. A solid concrete dam has been built across the gorge on the lip of this outcrop, and this, with the natural fall, produces a head of 70 ft.

As noted in photograph Fig. 3 the dam is of solid spillway type with an inspection and drainage tunnel. In addition to this spillway there are a number of sluiceways provided to take care of flood discharges. Inspection tunnel, access to which is gained by means of a well, situated between the flood discharge openings, extends under the spillway section into the rock at the west abutment of the dam. Four penstocks are installed leading from the intake to the power house, which is situated in the gorge below. The interior of the electric station of the Calgary Power Co., noted in Fig. 4, shows a portion of the complete power equipment, which consists of 4 turbines, 2 being of 3750 hp., and 2 of 6000 hp. capacity each. The electric generators are direct connected and produce their power at 12,000 v., this being stepped up by transformers to 55,000 v. for transmission to Calgary. A portion of the power is transmitted to Exshaw for use in cement mills direct at the generator voltage of 12,000 v. The transmission lines, in duplicate, are of aluminum cable on wooden poles.

As noted in Figs. 1 and 2, the hydro-electric development at the Kananaskis Falls is immediately below the junction of the Kananaskis and Bow Rivers, and about 2 mi. above the Horseshoe Falls. The head is composed of rapids and a series of 3 falls, giving a total drop of approximately 55 ft. Above the rapids, the Bow is wide and fairly shallow, while the banks are comparatively low, but gradually increasing in height to the head of the falls. Below the falls the banks are perpendicular, the river flowing through a rather wide canon. The banks of the Kananaskis are high, the west bank being perpendicular and rising at least 40 ft. above the surface of the stream; the slope of the east bank is more gradual for the first few hundred yards, but after that it is high and abrupt.

It is of interest to note that the development adopted includes a dam placed across the head of the falls, raising the water and diverting it into a canal excavated on the south side of the river, which conveys it to the intake. The water from the intake is conveyed in tunnels to the turbines in the power station. The turbines are of single runner type, with vertical shaft, and utilize the created head of 70 ft. The turbines are at present 2 in number, each of 5800 hp. capacity, direct connected to a generator. The voltages of 12,000 on the generator and 55,000 on the transmission line correspond to the characteristics of the electrical output of the Horseshoe Falls plant, to which it may be connected to operate in parallel, the 2 plants being owned and operated by the same company to serve the same markets.

FIG. 2. KANANASKIS DAM IN BOW RIVER

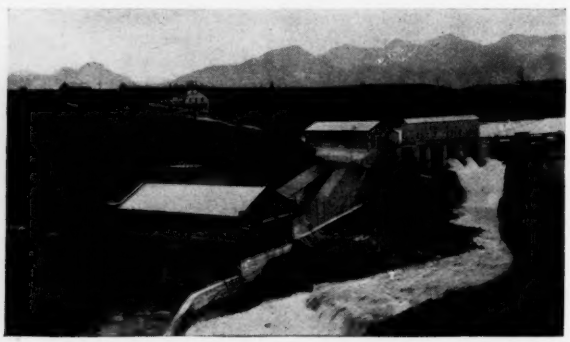


FIG. 3. BOW RIVER, HORSESHOE FALLS AND CALGARY POWER CO.'S DEVELOPMENT

It may be stated that the Bow Fort Site is located about 4 mi. below Horseshoe Falls at the foot of a number of rapids and swifts which aggregate 70 ft. of fall below the tailwater of the Calgary Power Co. The site available for the dam is excellent, as suitable foundation rock exists in the river bed, and the banks of the river are steep and rocky, and but 265 ft. from cliff to cliff. A head of 66 ft. may be created by the dam allowing 2 ft. leeway for operation of the Calgary Power

Co.'s tailwater. The intake, also constructed in solid rock, would be situated on the south side of the river and would direct the water into the 3 power penstocks, each proposed to supply a turbine of 4400 hp. capacity, coupled to a generator of 2500 kw. with exciter direct connected. This power site is ideal as the construction works are simple and comparatively inexpensive.

Engineer Mitchell states that the cost has been estimated from the preliminary plans prepared for the development along the lines here outlined, and aggregate a total of $138 per hp., including a proportionate cost of transmission to Calgary, along with the other proposed plants further down the river. The annual cost, per horsepower, on a 100 per cent load factor, is estimated to be $15.93. All costs given for these sites are for the rated capacity of the equipment and for power delivered in Calgary; the stations are capable of operating on a 25 per cent overload above the rated capacity continuously.

It is pointed out that from Bow Lake, the source of the river, down to Laggan, the river flows for the most part through a wide valley in the midst of towering mountains. Below Laggan, as far as Kananaskis Falls, the valley traversed is wide, flat and covered with gravel, and the stream is tortuous in its course. In 2 or 3 places in the main valley above Banff small lakes occur, probably formed by the damming off of part of the old river course by the material carried down from the surrounding mountains. Below Banff, near Exshaw, the river widens out and covers the greater part of the valley.

At Kananaskis Falls an abrupt change in topography of the country takes place; this, it may be said, is due to the fact that the river leaves the mountains proper here and flows out into the foot hills, these conditions continuing as far as Calgary. The Elbow River flows into the Bow immediately below Calgary from a southerly direction. From Kananaskis Falls nearly to Calgary the river flows through a wide valley for long stretches; the river proper is confined to its channel by steep banks that at different points are rocky cliffs of considerable heights running as high as from 100 to 150 ft. Generally these cut banks have long sloping banks opposite to them, but in places the river channel is canon-like for short stretches and is thus readily adaptable to power development works.

It is of interest to note that the storage section of the river, a stretch of approximately 90 mi. in length, lies to the west of Kananaskis Falls, and entirely in the mountains. Nearly all the streams flowing into the Bow River have, at or near their source, a lake of greater or less size. The larger lakes include the Bow and Hector lakes at the highest elevations; Lake Minnewanka, near Banff, at the head of Cascade River; the Spray Lakes at the head of the Spray River; and at the headwaters of the Kananaskis River, Kananaskis Lake. Other lakes, many far famed for their scenic beauty, which are extremely valuable for their regulating effect, but not so suitable as controlled storage basins, include Lake Louise at Laggan; Ptarmigan, Baker and Redoubt Lakes, Moraine Lake, in the valley of the Ten Peaks.

Engineer Mitchell points out that all feasible storage on the Bow River above Calgary is fortunately available for the whole water stretch of the river. The mean flow for the winter months has been 720 cu. ft. per sec.; but by means of the storage that has been, and may be, ere-

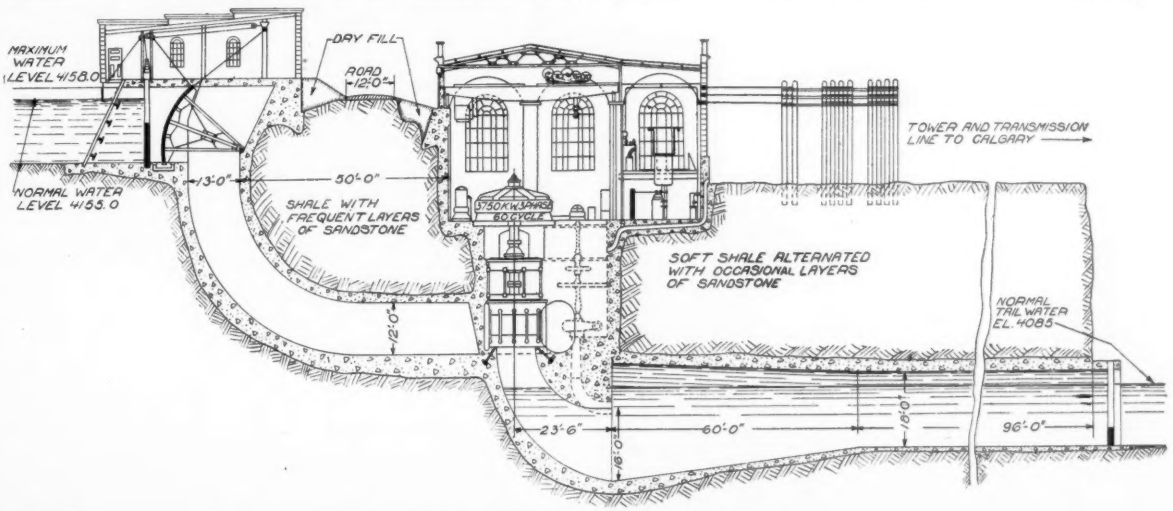


FIG. 5. CROSS-SECTION OF KANANASKIS FALLS PLANT

ated, it is anticipated that the mean flow can be increased to about 1500 cu. ft. per sec. The effect of such storage upon the power output is to raise the winter mean output of 19,785 hp. on 6 other water power sites, to 48,175 hp., and in addition a plant to be constructed on the Cascade River and supplied by water in transit from the Minnewanka storage lake would be capable of producing 1165 hp. The Minnewanka storage system is now complete and includes a dam shown in illustration Fig. 6 at the head of the Cascade River. The gorge immediately below the dam is called the "Devil's Canon."

It is claimed that within the provinces of the Dominion of Canada and excluding the Northwest Territories, practically all of the Yukon, and the northern and eastern portion of Quebec, it is estimated that 17,764,000 hp. is available, this amount being inclusive, in the case of Niagara Falls, Fort Frances and the St. Mary's River at Sault Ste. Marie, of only the development permitted by international treaties, and further does not contemplate the full possibilities of storage for the improvement

of capacities. The developed powers which are inclusive of all water powers, whether for electrical production, pulp grinders, for milling or for the great many other uses, aggregate 1,711,188 hp.

It is declared that the Prairie Provinces are essentially agricultural, and Red Fife and Marquis are names to be conjured with in the wheat markets of the world. The deep rich prairie soil is a mine available to hundreds of thousands of farmers whose dividend of golden grain is never failing.

Settlement of the great west has been fabulously rapid and the industrial development has far from kept pace with the agricultural requirements; the industrial era has, however, dawned, and it is to be expected that in the near future the local consuming market will be to a great extent satisfied by local manufacturers. The uses of electric power in an agricultural country are three fold; first, directly applied to the production, operation and marketing of the products and natural resources; second, for manufacturing purposes in the supplying of the market created by the people of such a country; and third, in the community life, the public utilities and transportation.

Engineer Mitchell holds that it is hard to predict the future of electric power under such conditions. The enormous strides of the last 20 yr., in reality the period

FIG. 6. MINNEWANKA DAM AT BANFF, ALBERTA

since the establishment of the first commercial electric transmission system, has developed established loads necessitating in the United States and Canada alone the development of water power plants aggregating nearly 10,000,000 hp., the last 10 yr. more than the first 10 yr. in the rate of growth. The load curves showing the growth in power requirements from year to year in each of the large cities of Canada, show an increase from very small dimensions of from 5 to 10 yr. ago to enormous demands, and at a rate of doubling in from 1 to 3 yr., and with the curve of the load diagram indicating most vigorously similar increases in the years to come. While it is quite apparent that the greatest portion of these loads is consumed in the older districts of the Great West, the population and the quantity of output is, too, increasing rapidly, adding a new factor of growth to the swelling power demand, the combined effect of which is readily borne out by the evidence of the respective records.

The water powers of Manitoba, Saskatchewan, Alberta, the Northwest Territories and the Yukon are under control of the Dominion Government. The Dominion Government water power policy as administered by the Water Power Branch of the Department of the Interior, affords every reasonable protection to the public as to rentals, periodic revisions, control of rates and limited grants, and at the same time fosters legitimate private enterprise to return reasonable profits while the regulations in force afford all possible assistance to the development of water powers which have reasonable assurance of economic utilization.

Cooling Condensing Water by Wholesale

COMBINING THE INTEREST OF SOME 26 PLANTS, ENGINEERS HAVE DEVELOPED PLANS FOR SUPPLYING THEM WITH GREATLY IMPROVED CONDENSING WATER. BY WALTER B. SNOW

THE favorable location of Fall River, Mass., for manufacturing purposes, with a river flowing through its heart, a tidal harbor on one side, and water storage in the largest fresh water ponds in Massachusetts at high level on the other, has led to the building up of the largest cotton manufacturing center in the country. But the mills have clustered themselves along the river, and their number has increased to such an extent as to create conditions requiring immediate improvement. During the past 2 yr., the problem has been studied exhaustively by a special commission, and its engineers, Fay, Spofford & Thorndike, of Boston, with the result that a plan is now proposed which would do away with the existing nuisances and insure an ample supply of water to the mills.

Years ago, a dam was built in the lower course of the river (the Quequechan) which raised the level of the water above by about 5 ft., and overflowed a large area. Although this has been gradually filled in, there remain large areas of open water. It is from these areas that the mills on the upper reach of the Quequechan River draw their water principally for condenser uses, and to which they return it. As this water is used over and over again, there is no limit to the amount which can be drawn in this manner. The 26 plants (including 33 separate mills—some of the plants consisting of 2 or more mills) at present draw from this upper reach of the river a maximum of about 30,000,000 gal. of water a day. Nearly all of this is used for condensers. But the daily flow of the stream itself sometimes falls as low as 5,000,000 gal. a day in dry times. It is therefore evident that every drop of water flowing at such a time must pass through 6 condensers in its course down the river to the dam.

It is obvious that under such conditions the water above the dam must become excessively heated during dry seasons, the temperature increasing as the water flows down stream and being at a maximum just above the dam. The worst condition on record occurred on Sept. 26, 1909, when the flow was reduced to a minimum and the temperature of the water in the river just above the dam rose to 120 deg. This reading was taken at 3:35 p. m., and as naturally would be expected, it was higher

than it would have been in the morning after the water had a chance to cool during the night when the mills were not running. With an intake temperature of 120 deg. to the condensers, it is obvious that the vacuum must be materially impaired.

Although this is a maximum record, frequent readings have been taken at the mill intakes which show temperatures range from 90 to 100 deg., while the temperatures at the outlets of the discharges from the mill condensers show many readings from 120 to 130 deg., and a maximum reading of 142 deg. The range of temperatures at certain mills as recorded are shown in the accompanying diagram. The conditions are such that it is a common sight to see steam rising from the lower portion of the river surface when the mills are running with the river low.

The plans of the engineers provide for drawing the supply pond down to a depth of 8 ft., where 4½ ft. is the maximum allowable draft today, and the storage of water during wet months for use in dry months, so as to equalize the flow throughout the year. Under these conditions, it would be possible to deliver 20,000,000 gal. down the river for every working day, as against the minimum of 5,000,000 at present obtainable.

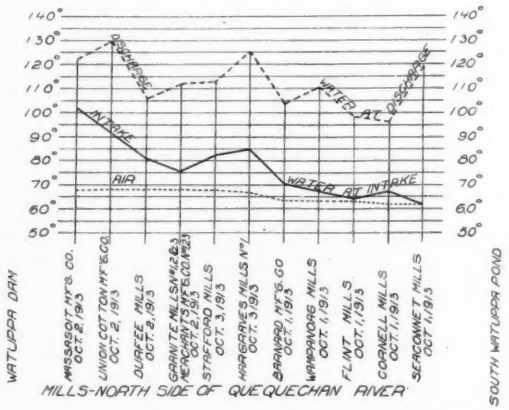


FIG. 1. TYPICAL TEMPERATURE READINGS OF CONDENSING WATER FROM THE QUEQUECHAN RIVER

To meet the present mill difficulties and improve the sanitary conditions, it was necessary to provide for the supply of clean, cool water to the mills, the removal of the condenser water, and ample area to take away surface water in time of heavy rain. The engineers have solved the problem in a unique manner by planning to collect the condenser water from all of the mills and transport it by gravity to an oil separating basin, whose function will be so to retard the flow of the water discharged from the mill condensers that most of the oil contained in the water will be separated and rise to the surface, where it may be removed.

The basin consists essentially of a long, narrow reservoir divided into 2 compartments by a central partition wall. At the inlet end, provision is made to distribute the water uniformly across the full depth of the basin. At the outlet end, there is a wall with outlets for the hot water at the bottom and skimming weirs and channel in the top. By means of the latter, the oil may be skimmed from the water and conducted to an oil storage tank from whence it can be removed when convenient, several times a year.

Two submerged weirs are built across the basin compartments to prevent currents being set up which would disturb the rising of the oil, to assist the oil to rise by carrying it near to the surface, and to prevent the wind from causing serious wave disturbance.

This basin is designed to care for the present needs of the mills, with the expectation that another of similar size will be built in the future to care for the anticipated increase in hot-water discharge. At the present maximum rate of discharge, the hot water will remain in the basin about ¾ hr., and experiments have shown that all the oil, except that thoroughly emulsified, may be expected to rise within this time.

The walls of the basin are of reinforced concrete, supported on piles where necessary. At the location selected, no excavation for the basin proper is needed except beneath the walls. No artificial bottom has been thought necessary. To facilitate cleaning the basin in the future, the tops of the side and dividing walls have been carried to the same level so that a dredging machine can be easily designed to run on them.

The cooling basin, which the hot water enters after leaving the oil-separating basin, has an area of about 8 acres and an average depth of about 6 ft. It will

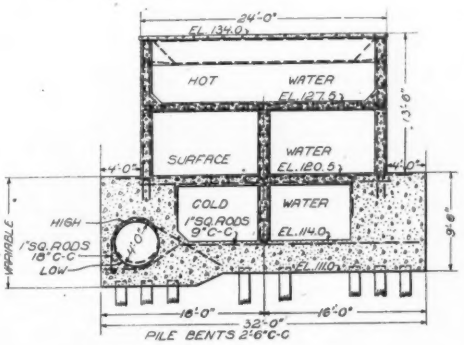


FIG. 2. MULTIPLE CONDUIT USED IN CONDENSING WATER SYSTEM

hold about 5 hr. discharge of hot water, so that, in this and the oil-separating basin, one-half of the day's discharges will be held overnight and will get the greatest cooling possible, the remaining half being spread over the surface of the supply pond after a few hours' cooling in the basin.

The object of the cooling basin is to prevent objectionable rise in temperature of the water of the pond. Under the worst conditions of maximum summer temperatures, it is expected that the hot water passing through the cooling basin during the day will lose about 3 or 4 deg. of heat, while that remaining in the basin overnight will lose about 10 deg. Under ordinary conditions, a still greater loss of heat will be effected. By the proposed arrangement, it is believed that the temperature of the water drawn for mill use at the cold-water intake will be scarcely, if any, higher than it would be if no water from the mill condensers were discharged into the pond.

The depth of water in the cooling basin is maintained regardless of the elevation of the water in pond by means of a weir; this consists of an earth fill, covered with stone block paving. The crest of the weir is placed about 2½ in. below full pond level. When the level of the pond is low, additional cooling will be obtained by the warm water passing over the weir and down the paved slope.

The water discharged from the cooling basin will pass under a wooden bulkhead before reaching the weir; thus, only the cool water from the bottom of the basin will be withdrawn.

In order to conduct the hot water to the separating basin and distribute the cool water to the mills, while providing for handling of surface water, the engineers designed a unique multiple conduit, as shown herewith.

The magnitude of this undertaking is shown by the fact that the present mills above the dam when running to full capacity develop a total of about 55,000 hp., and consume about 90 cu. yd. of water a second, or nearly 30,000,000 gal. a working day, principally for condenser purposes.

The carrying out of this plan awaits formal action on the part of the City Council of Fall River.

Furnaces Which Prevent Smoke*

ARRANGEMENTS AND ELEMENTS OF DESIGN TO MAKE FIRING EASIER AND INCREASE ECONOMY. BY OSBORN MONNETT

CONVENTIONAL settings may often be changed at slight trouble and expense to give great improvement from a smoke standpoint, where high volatile, long flaming coals are used. The type of boiler or furnace has less bearing on smoke performance than putting the combination together so that both have a chance to give the best results.

HIGH PRESSURE POWER BOILERS WITH CHAIN GRATE

PLATE 1, Fig. A shows in outline an old type, chain-grate setting with a 3½-ft. ignition arch, the stoker being set under the boiler with a clearance of 6 ft. from floor to front header. This setting is typical of the older practice in chain-grate setting, with low, short, flat arch, poor ignition and low capacity. The deadening effect of the bank of tubes is such as to extinguish the flame before combustion has become complete, in the same manner that a wire netting will kill the flame from a gas burner, the result being a great deal of smoke. While this setting gives short flame travel, mere length of flame travel is not always enough to insure a satisfactory setting, unless some positive means are provided to cause a mixture, the gases frequently become stratified, in which case combustion can not be complete.

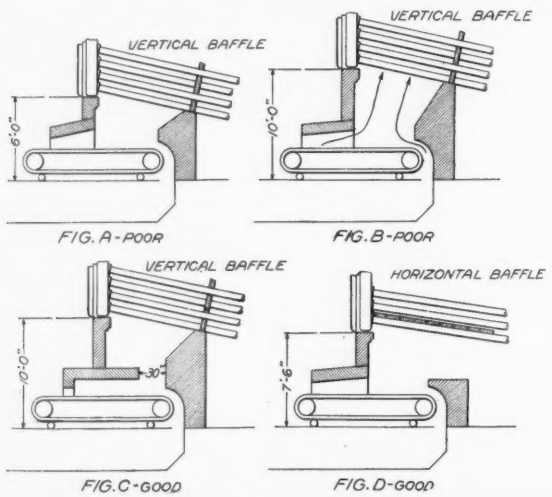


PLATE 1. TYPES OF CHAIN GRATE SETTINGS

In Fig. B, Plate 1, the boiler has been raised to 10 ft. under the header; the ignition arch lengthened to 5 ft. and set full extension, which allows more flame travel, but the setting still has some of the defects of the first one and is not good for high capacities. One of the principal defects is that the flow of rich volatile matter may pass into the bank of tubes in an uninterrupted current in the front part of the furnace, while most of the oxygen necessary to burn this volatile matter is passing in at the back part. There is a lack of mixture and consequently incomplete combustion and low economy.

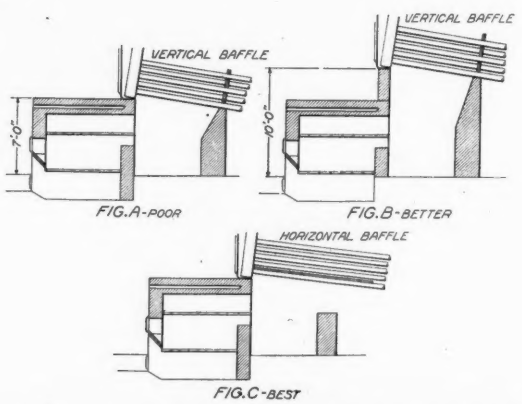


PLATE 2. DOUBLE INCLINED STOKERS AND HORIZONTAL WATER-TUBE BOILERS

Figure C, Plate 1, corrects the above defects by using a longer arch, setting the stoker farther under the boiler, decreasing the floor space occupied and narrowing up the furnace throat opening so that the volatile gases and air mix in a high temperature zone, which easily completes combustion on a 10 ft. setting. Experiments have shown that for commercial use the best throat opening is from 18 to 36 in., the smaller ones being high in maintenance; 30 in. is about the most satisfactory for all around use.

Another factor, which has had a marked effect on the performance of the later chain-grate settings, has been the height of the ignition arch at the grate; where 11 in. was formerly the standard height for a flat arch, it has now been increased to 15 in., and the slope of the arch

*From a paper before the Ohio Society of Mech. Elec. and Steam Engineers.

has been increased to 2 in. or 3 in. per ft. Where the arch is sprung across the furnace, it is now set level, 9 in. above the grate at the skewback, with a 9-in. spring, making 18 in. at the center of the arch.

For the horizontal baffle little need be said from the smoke standpoint as this combination is always satisfactory. Fig. D, Plate 1, shows a setting with 7 ft. 6 in. head room, which can be considered ideal for a chain grate. This dimension may vary considerably without affecting the performance. 6 ft. 6 in. may be considered the minimum head room allowable.

It sometimes happens that, with a tile-roof furnace and a low setting, the furnace gets so hot as to have a bad effect on the life of the brick work. This can be offset in many instances by baring the lower row of

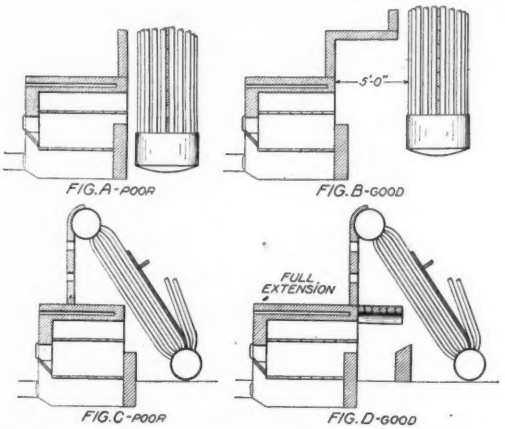


PLATE 3. DOUBLE INCLINED STOKERS AND VERTICAL BOILERS

tubes, using T tile instead of box tile. This allows more rapid heat absorption into the boiler, increasing the life of the brick work and resulting in a better operating furnace.

Double Inclined Stokers

For the double inclined type of stoker the short length of flame, discharging directly into the bank of tubes, is undesirable when the fire is being worked. This type of setting is frequently found installed in a 7-ft. head room, as in Fig. A, Plate 2. The human element enters strongly into the matter with such a setting, owing to the possibility of having considerable volatile matter pass off rapidly through carelessness. With a case of this kind it is better to set the boiler with a clearance of 10 ft. as in B, giving more opportunity for the gases to complete their combustion. One of the safest arrangements is to provide a tile roof setting with an auxiliary bridge wall, Plate 2, Fig. C, breaking up the current of gases and insuring the mixture of any excess amount of volatile matter which may pass off for any cause whatever. The importance of setting this type of furnace with maximum flame travel is not always realized.

In Plate 3, 2 different types of boilers are shown with good and bad combination of double inclined furnaces. It is a safe rule to get a full extension on this type of furnace and never resort to the flush front setting. In the case of Fig. A, Plate 3, the defect of short flame travel is corrected by providing a 5-ft. dog-house extension between the boiler and furnace and by raising the boiler to get the full benefit of the heating surface as shown in Fig. B. Typical Stirling settings are shown in C and D with flush front and full extension furnaces.

Front-Feed Stokers

With the front-feed stoker the same practice should be observed as regards flame travel. A clearance of 7 ft. is not sufficient to get good results with this type of stoker and vertically baffled, water-tube boilers. A much improved furnace can be obtained by using a head room of 10 ft. as in Fig. B, Plate 4, a combination resulting satisfactorily from every standpoint. This design also gives an opportunity for employing a vertical bridge wall, which is nearly always found to be a desirable feature wherever it can be used, as the radiating surface of the hot brick helps to keep the gases hot as they pass out of the furnace.

With a horizontal baffle it is a simple matter to combine this type of stoker successfully. Sufficient head room only is required to get the stoker under the front header. If this cannot be secured in the head room

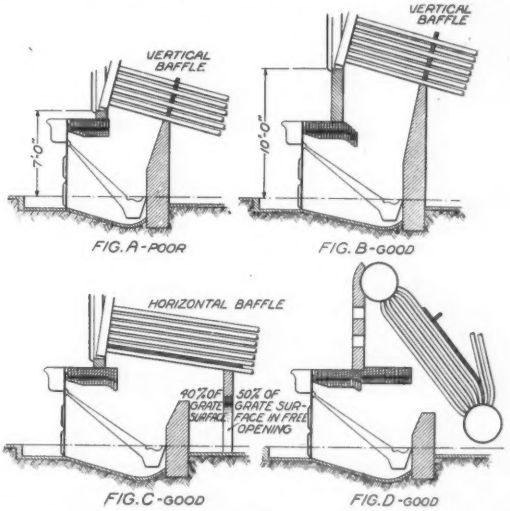


PLATE 4. FRONT FEED STOKERS WITH VARIOUS BOILERS

available, it does not alter the effectiveness of the design to excavate as shown in Fig. C. Sometimes piers, or deflection arches, are used with this setting to break up the current of gases. Where a free opening in such a setting does not go below 40 per cent of the grate surface of the stoker, such construction is desirable. On a vertical boiler always get the maximum extension possible within reason.

Underfeed Stokers

Different types require different head rooms. See Plate 5. The Jones and American types can give excellent results with a head room of 8 ft. 6 in. for a vertically baffled boiler, Fig. B, and 7 ft. for a horizontally baffled boiler. In the case of the former the effort should be to provide enough flame travel to minimize the danger of unconsumed volatile matter passing into the bank of tubes.

In the case of tubular boilers the above named types of stokers can be installed with 42 in. from the dead

plate to the shell, Fig. C, and the combination will result in a satisfactory performance. With stokers of the inclined type, Fig. D, a 10-ft. clearance under the front header makes an ideal combination.

Hand-Fired Settings

One of the most common types of boiler setting encountered is the ordinary hand-fired, return-tubular setting such as is indicated in Fig. A, Plate 6. In this setting there is no attempt made to accomplish a mixture of the gases after they have passed the bridge wall. The

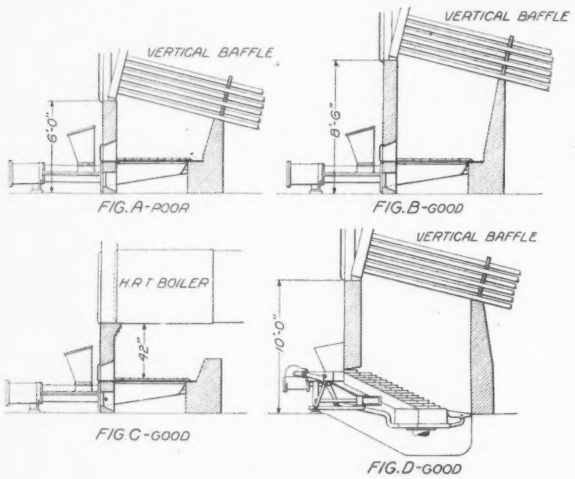


PLATE 5. HEAD ROOMS FOR UNDERFEED STOKERS

setting, while fairly efficient commercially, is very smoky with high volatile coal, and many attempts have been made to improve it. Fig. B, Plate 6, shows a full-extension, dutch-oven setting by which it was attempted to improve the plain, hand-firing setting. From a smoke standpoint the dutch-oven setting is a poor combination.

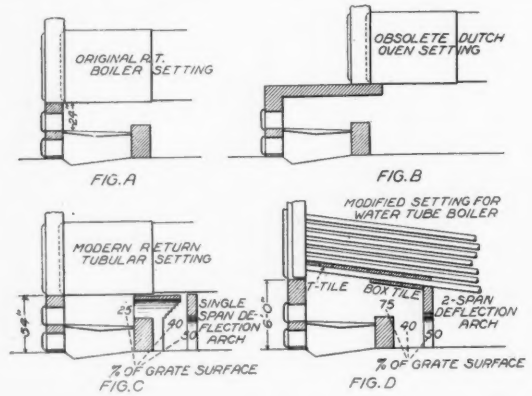


PLATE 6. DEVELOPMENT OF HAND-FIRED FURNACE

Contrary to stoker practice where the fuel is introduced slowly and in small quantities, there is a considerable quantity of coal thrown on the fire at once. The strong radiation from the brick work above the fire has the effect of distilling the gases so rapidly that puffs of dense smoke will be made after firing in spite of every effort to prevent them. Fig. C, Plate 6, shows how to correct this defect by baring the shell to the direct radiation of the fire. This increases the steaming capacity and provides a high temperature zone back of the bridge wall where the gases must mix positively against the deflection arch, which breaks up the stratification and so promotes combustion.

It is not practical to combine a hand-fired, coal-burning furnace with a vertically baffled, water-tube boiler, but it is a simple matter to arrange such a furnace with a horizontal baffle, carrying out the same idea as in Fig. C. The ordinary hand-fired, horizontally-baffled, water-tube boiler furnace is covered with box tile and has nearly all the defects of the dutch-oven shown in Fig. B, as it is practically a fire-brick enclosed furnace from which the volatile gases will be distilled at a rapid rate. Fig. D indicates how this can be overcome. The changes indicated are, first, baring the tubes over the fire, using T tile, thereby avoiding the radiating effect of a mass of fire brick; second, installing a 2-span deflection arch to break up the current of gases, as in the case of the return tubular boiler. In both of these furnaces a few

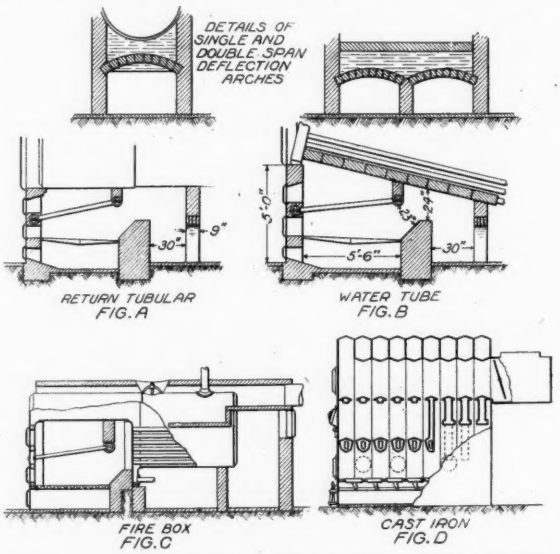


PLATE 7. DOWN-DRAFT SETTINGS FOR HEATING LOADS

simple proportions should be carried out to insure satisfactory results.

There should be from 20 to 25 per cent of the grate surface in free opening above the bridge wall. The free opening from the back of the bridge wall to the deflection arch should not be less than 40 per cent of the grate surface, while the free opening under the deflection arch should be 50 per cent of the grate surface. Hand-fired furnaces for high pressure work should be fitted with 4 air-siphon steam jets, spaced across the furnace above the fire doors, to be used when necessary.

Low Pressure Heating Plants

The foregoing discussion has been with reference to high pressure power work. The low pressure heating plant presents a problem that in some respects is more difficult than any encountered in high pressure work. The plants are not ordinarily large enough to justify stokers, and, even if such was the case, the character of the attendance is not such as would do justice to the equipment. The temperatures are lower and no steam

is available for steam jets or for power to drive apparatus. With such conditions as these to meet it has been found that the down draft principle works out very well.

A little study will show why this is so. The danger of making smoke on a down draft furnace comes from getting green coal on the lower grate, so the longer the fire can remain undisturbed the less chance of making smoke. The rate of combustion on heating loads is low, and allows for long periods during which the fires are not disturbed and no smoke is made. During these undisturbed periods there is accumulating on the water grate a thick bed of coked coal, which, when sliced down to the lower grate, does not make smoke because all volatile matter has been distilled off. After slicing, the fire can be heavily charged with fresh coal, without disturbing the fuel bed, consequently without causing smoke. It is then in shape for another long undisturbed period.

Another advantage of the down draft principle on heating loads comes from the fact that although the rate of combustion may be at times extremely low, yet the water element directly in the fire furnishes a proportionate amount of steam no matter how low the combustion; so the system is more responsive than would be possible with a plain grate boiler.

The down draft principle can be applied to return tubular or water-tube boilers in the larger units. In these units it is advisable to spring an arch in the path of the gas as shown in Figs. A and B, Plate 7. As the rate of combustion on these large units at times approximates power conditions, it is desirable to guard against any excessive amount of volatile matter, which might pass over during these periods, by breaking up the current of gases and giving them an opportunity to burn.

For small units there has been developed in the past few years a number of types of self-contained, steel and cast-iron boilers embodying the down draft principle. In the former type, Fig. C, the water element consists of water tubes or pipes extended into headers in the ordinary manner and located in the fire box of a locomotive-type boiler. In the cast-iron, down draft type, Fig. D, the water element is cast integrally with each section, forming the upper grate, the shape of the elements being such as to facilitate the slicing of coked coal down to the lower grate without disturbing the main body of fuel before the volatile matter has been distilled from it. This type is made in sizes up to 10,000 sq. ft. of radiation in one unit, and can be installed several in a battery.

In conclusion, I wish to call attention to the necessity of being in possession of all the facts before attempting to work out any given smoke problem. There are so many variables such as head room, floor space, character of attendants, fuel, etc., to be taken into consideration that each job requires careful study before any recommendation can be made. When proper attention is given to the matter there is no question but that an installation can be obtained which will meet the local conditions and operate with the minimum production of dense smoke.

Efficient Operation of Boiler Rooms

A New Plant Serving an Institution Has Proper Start Towards High Efficiency, But Lacks Some Instruments

IN this article the plant under consideration serves an institution with practically all its needs in the mechanical line, including electric light and power, steam heat, water, sewage disposal, steam and power for laundry, refrigeration, etc. The service is extremely diversified, but the load factor runs comparatively high without a pronounced peak load on the boilers.

The boiler plant consists of 6 water-tube boilers, made by the E. Keeler Co., each with a capacity of 350 hp. based on a rating of 10 sq. ft. of heating surface to the horsepower.

The boilers are arranged in 3 settings, 2 boilers to each setting. The front of the setting is built in structural steel work which supports the front of the boilers by means of a yoke; at the back the boilers are supported by the brickwork of the setting.

Under each boiler are 2 hoppers; the front hopper is of metal and extends about half way under the chain grate stoker, being used to catch the unburned or partially burned coal, which is delivered to a bucket conveyor and used over again.

The back hopper is placed so as to catch the ash and clinker as they are dumped from the end of the stoker. This hopper is lined with firebrick and provision is made for wetting down the ash before it is dumped into the conveyor.

Settings are solid brick walls, 12 in. thick, except between boilers, where an air space is left, pressed brick being used on the outside, while parts exposed to heat are of fire brick all set in cement mortar.

Five of these boilers have vertical baffles, while the sixth has horizontal baffles, all arranged for 3 passes, tile being used.

It is the aim in the operation of the boilers to run them at full load, forcing those in operation to take care of the peak, which means about 25 per cent overload under average conditions, though at times the demand has reached as high as 50 per cent overload. Feed water, however, is bad, and it is not considered wise to force the boilers excessively.

Grates

Illinois chain grate stokers serve the boilers, these being 7 ft. wide and have 70 sq. ft. of firing surface, set 7 ft. below the first tubes of the boiler. A short ignition arch spans the front of the stoker, but does not extend under the boiler tubes. The proportion of grate surface to heating surface is 1 to 50, and the air inlet space is about 21 per cent of the grate surface.

A water column is attached to the front head of one drum of each boiler; as the boilers are placed 2 in a setting, a water column is on each outside drum. In-

structions are to blow down the columns once every hour, and carry the water at 1½ to 2 gages.

The feed line enters the front of each drum near the bottom, and passes to a mud drum inside the steam drum at the rear. This is a cylindrical shaped pan, separated from the boiler shell by 4 legs. Water entering the boiler passes through the mud drum, where it is heated almost to the boiling point at the pressure carried, and slowly rises, depositing precipitates, and overflows into the back water leg of the boiler.

To each boiler are 4 blowoff lines. The surface blowoff pipes are attached to the mud drums and the bottom blowoffs to the lower part of the water legs. In each line is a Cadman valve backed by a Homestead plug, all discharge into one header leading to a blowoff basin. Each boiler is blown down every 8 hr., the procedure being to blow the surface first, then the bottom.

On each drum is placed a 4-in. safety valve, connected close to the shell near the front, set to pop at 150 lb. steam pressure. These are tested every day to see that they are not sticking. The 2 valves on each boiler discharge into a common pipe leading through the roof.

Boiler Operation

Chain grate stokers being employed, there is little to be said in regard to the method of firing. At the time of our visit the load was light, grates were traveling at the rate of 15 to 16½ ft. an hour, the depth of fuel bed being 5½ in. The coal used was Indiana screenings with a heat value of 10,000 to 12,000 B.t.u. per lb., and was considered low grade, being about 12 per cent ash. Much of it goes through the grate and has to be conveyed to the bunkers and fed over again. Firemen are given instructions to regulate the speed of grate and thickness of fire so that burning coal will not go farther than 1 ft. from the water back.

Draft is regulated by a hand operated damper for each boiler, 0.9 in. being available at the stack and 0.21 over the fire. No test has as yet been made to find the draft at the various passes, but provisions are being made to make these tests, then the baffles will be located to give a uniform drop through the boiler.

Coal is weighed as it is delivered to the plant in cars, but otherwise no provision is made for weighing, neither is there any method of measuring the water fed to the boilers nor the amount of steam developed.

There are at present no records kept nor provision made for determining various temperatures about the boiler plant, but a thermometer is being installed on the outlet from the feed water heater, also a pyrometer will be used to ascertain furnace temperatures. The temperatures of the flue gases has been found during tests to be 625 deg. F., when carrying steam pressure at 150 lb. No analysis, however, has been taken of the gases.

Water is pumped from wells and contains 34 gr. of hardness per gallon, and for use in the boilers is treated in a Kennicott water softener to a hardness of 10 gr., and discharged into a reservoir which also receives the rain water drained from the roofs of the buildings of the institution.

Cleaning the Boilers

The condition of the water is such that it has been found advisable to clean each boiler once a month. When a boiler is taken out of service for cleaning it is allowed to stand from 3 days to a week before the work of cleaning commences, then it is filled with water and tested at 110 lb. hydrostatic pressure and examined for leaks.

The boiler is then opened and as the water is running to the sewer a man is sent inside with a hose to wash down the accumulation of soft mud. Handhole plates are removed and the tubes cleaned with a turbine cleaner, plates are cleaned and examined, repairs made, new asbestos gaskets fitted, plate surfaces cleaned up and boiler closed and tested again with 110 lb. water pressure. When ready to start the water level is lowered to about 1 gage.

When cleaning the outside of the boiler tubes and shell the soot and dirt are first blown off with compressed air, after which any accumulation of scale or rust is scraped off and an examination made of all surfaces for blisters, bags and cracks.

Each boiler is equipped with a Bayer soot blower, which is operated every 8 hr., and effectively removes soot from the heating surfaces during operation.

As previously stated, there are 2 hoppers under the grate; the front hopper catches the fine unburned coal. Every 12 hr. this hopper is emptied into the buckets of a conveyor and carried to the coal bunkers. Ash which goes over the end of the grate is caught by the rear hopper, which is emptied once every 24 hr., and carried by the conveyor to a hopper which discharges by gravity into a railway car.

Coal is delivered to the plant in drop bottom cars and discharged into a hopper beneath the tracks. A plunger at the bottom of the hopper feeds the coal as desired to the motor operated bucket conveyor, which elevates it, carries it over the bunkers in the front of the boiler room and dumps it in the desired bunker, from which chutes lead to the stokers.

Air Leaks

An interesting method of discovering air leaks in the walls of the settings is employed in this plant. After the boiler has been cut out of service for cleaning and before the tubes have been cleaned, in other words, before the soot on the lining of the walls has been disturbed in any way, a man is sent into the setting with an extension lamp to examine the condition of the walls. Any crack or crevice which allows air to enter will be evident by the soot being blown from the wall around it. Any such cracks are stopped up with asbestos cement.

Holes in the baffles are detected by holding a bright light on one side while the observer is on the dark side, where holes are revealed by beams of light. These are also stopped with asbestos cement.

To detect air leaks while the boiler is in operation, the method employed is to shut the damper for a minute and all hands watch for streams of smoke.

The rate of combustion is, on the average, about 20 lb. per sq. ft. of grate surface per hour, but has at time of peak load gone up as high as 35 lb., and the evaporation is on the average about 6½ lb. per lb. of coal.

Boiler Feed Water-VI

SOME COSTS OF POOR WATER. BY F. F. VATER

WE must now bring our chart up to date, or something will be forgotten.

Bracket lime and magnesia. Write scale effect, then bracket. Write halfway up, Lime; halfway down, Magnesia. Bracket Lime, and write Sulphate—Dense Hard Scale, Bicarbonate—Light Porous Scale; Chloride—Corrosion, Hard Scale; Nitrate—Corrosion, Hard Scale.

Bracket magnesia, and write Sulphate—Dense Hard Scale; Bicarbonate—Light Porous Scale; Chloride—Corrosion, Hard Scale; Nitrate—Corrosion, Hard Scale.

Chloride of lime is corrosive because upon the application of heat, the chlorine is released, combining with the water as hydrochloric acid. The lime precipitates as an oxide, which forms a hard scale; with nitrate of lime, the same effect follows; nitric acid is released; lime oxide precipitates.

The sulphate of magnesia in itself will not form a very hard scale, but its effect is the same as lime sulphate; as when the magnesia and sulphuric acid separate, the sulphuric acid goes to the lime, if any is present, forming lime sulphate, the magnesia precipitating as an oxide. If no lime is present to take up the sulphuric acid, pitting and corrosion will follow.

The oxide of magnesia, like the oxide of lime, forms hard scale, but not so hard as the lime. The bicarbonate of both these salts in themselves forms an open porous scale. The reaction of the chloride and nitrate of magnesia is the same as lime.

Write General Effect as indicated to cover all incrusting solids. Then bracket and write, Increased Density, causes, Coal Waste, Increased blowing down, Tube Loss, Burned Plates, Turbining Tubes, Chipping plates, Increased labor with possible foaming.

Coal waste is three-fold. First, the water being dense, more heat is required to force the steam bubble to the surface of the water, as previously described. As far as I know, what this loss is has never been determined; so a definite fixed cost cannot be given.

Second, is that waste due to cooling down a boiler, getting it ready to clean, then heating it up ready to cut into the steam line. My observation is that this loss is pretty uniform for different types and sizes of boilers.

If a plant is hand fired, this loss will run to 10 lb. of coal per horsepower. That is, to cool down and heat up a 100-hp. boiler, hand fired, will require 1000 lb. of coal. The ratio holds good for other sizes hand fired, so that a 400-hp. boiler will require 4000 lb. or 2 tons of coal in the operation.

For stoker fired boilers, this loss conservatively stated, will run to 12½ lb. of coal per boiler horsepower, meaning that it will require for a 500-hp. boiler stoker fired, 6250 lb. of coal for the operation.

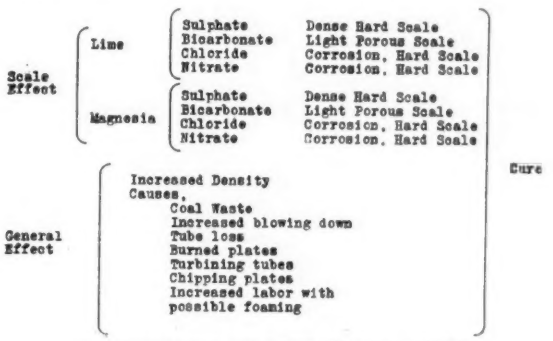
You can check this against your own practical experience, and determine the loss for your own plant by doing a little weighing. After experimenting, you will find this is about right. If there is any error, it is in making the statement too conservative.

The third loss is that caused by the scale insulating the heating surfaces. This is very difficult to average. In a scale formed of carbonate of lime and magnesia, the loss will not be high because the deposit will be open and porous. As the scale grows denser, due to the presence of sulphates, the loss will increase.

Again, a boiler seldom scales the same thickness all over, especially in water-tube boilers. The lower tubes may have ⅛ in. in thickness, and the upper, less than egg shell thick. Tables giving the loss due to scale are, therefore, misleading. In the vertical type of water-tube boilers, those tubes carrying the entering water will have the most scale.

I have seen exceptionally bad cases where the scale was hard and there was lots of it, that the loss was probably as bad as 20 per cent. In other cases, it would not be 10 per cent, and where tubes are turbined regularly and frequently, the loss would not exceed 2 per cent.

Each particular case will have to be determined by the quality of water and frequency of cleaning. Unfortunately, few plants are equipped to permit of knowing for yourself under the conditions in your plant, by running an evaporative test immediately before cleaning and immediately after.



CONTINUATION OF FEED WATER CHART

Inasmuch as the effect of scale is cumulative and from the day the boiler is cleaned until the day it is cleaned again, the loss is increasing, you can by the 2 tests know your average loss.

There is another loss from cooling down and heating up for cleaning, that is severe in plants operating 24 hr. a day, and that is, the damage to the brick settings, which the contraction and expansion causes. Settings do not burn out, as a rule, from heat. The damage comes from change in temperature. Where boilers are cleaned every 3 weeks, I have seen the loss run to more than $1 per hp. per yr.

On the other hand, I have seen a blast furnace subject to much higher temperatures than are ever obtained under a boiler fired with coal, operated continuously without repair for 6 yr.

I do not mean to imply, that if you operate a setting continuously, it will never require repair, but to make

clear that with the best of material and labor the repair account is greater when frequent cleanings are the rule.

Blowing down costs money. It has to be done, of course, but the less often, the better. Anything that cleans your water by reducing scale formation and at the same time, reduces density (these 2 effects do not always accompany each other), means a saving in dollars and cents. This saving can be estimated very closely.

If you have a boiler 72 in. in diameter, 18 ft. long, and carry your water line 16 in. above the center of the boiler; say you blow down an inch on your gage 4 times a day, your water loss for the day is 1868 lb. If your pressure is 150 lb. and the feed water temperature is 200 deg. F., your loss is 165.7 heat units per pound of water, or 309,527.6 heat units. Again, if you are burning a coal which delivers 7000 heat units into the boiler water per pound, you have lost 44.2 lb. of coal. This would mean a coal having about 11,700 heat units per pound.

If coal cost you $2 per ton, the blowing down would cost you about 4½ cents in coal. This is a very small loss and only begins to count if you have a large plant and a bad water.

This shows very plainly that blowing down is much less expensive than losing a tube or wrecking an engine with foaming. You can never break your employer by blowing down. A leaky blowoff cock will do from 10 to 50 times as much damage.

Tube loss is expensive. In a large plant, well equipped to replace tubes, it costs $7.50 for each 4-in. by 18-ft. tube they replaced. This is cost of tube, freight, handling and the labor involved in cutting the old tube out and putting the new in.

Generally, this cost will be $10 per tube; this is only part. If the boiler was 400 hp., stoker fired, your coal loss due to cooling down and firing up is 6250 lb. of coal or 3⅛ tons at $2 per ton; $6.25. The boiler cost installed, say $6000; interest on this sum at 6 per cent is equal to $1 per day. If it was out of service 3 days, it cost $3. Every tube lost, therefore, cost the owner $19.25. If the average loss was 5 tubes per month, $96.25 is the loss and for 12 months, $1155. If the plant had 5 boilers, the annual loss would be $5775.

Such a loss is rarely met, but I have known of cases when bad water cost 50 per cent annually of the cost of the boiler plant. Practically, the boiler plant was renewed every 2 yr.

I do not come in contact with horizontal tubular boilers enough to know what it costs to cut out burned tubes, weld on safe ends, and put the tube back in place. It varies radically.

If your plant is in a town which has a good boiler shop, it would not cost half as much as if you had to send 50 or 100 mi. for the boiler maker. In addition to the maker's bill, you have the coal loss and the loss of interest on the investment, while the boiler was out of service. The cost of patching a burned plate is material. It will cost something to heat a plate and drive back a small bag. If it becomes necessary to put in an entire new plate, the cost will be heavy and seldom, if ever, will the boiler be as satisfactory.

(To be continued.)

American Engineer Awarded Rare Medal

JAMES FORGIE, consulting engineer of New York City, is awaiting the receipt of a Telford Gold Medal which was awarded to him by the Institution of Civil Engineers (Great Britain) in recognition of his paper on "The Laxaxalpam Aqueduct Tunnels in Mexico," and of his achievement in engineering the subject of the paper. The award was formally announced at the meeting of the Institution on Nov. 2.

Few men in this country have received this honor. Among them are Col. W. H. Harts, William Barclay Parsons, W. J. Wilgus, and J. V. Davies. The medal is about 3 in. in diameter, and has on one side a head of Thomas Telford, founder of the Institution, which was incorporated in 1828 but in existence long before that time, and on the other the famous Menai Suspension Bridge of North Wales. The name of the recipient is inscribed around the edge.

Mr. Forgie has for many years been prominently identified with the solution of rapid transit problems in cities; notably in New York, the Pennsylvania Railroad tunnels and the Hudson and Manhattan tunnels under the Hudson River, and is an authority on tunneling and construction works of a subaqueous character. He has engaged in many large engineering projects, both here and abroad and is a member of the American Society of Civil Engineers as well as the British Institution.

In his twenties, 20 yr. ago, he helped to solve the difficulties connected with the growing density of traffic in the first underground electric railroad in London. At that time, 2½ to 3-min. headway between trains was considered as close as they might safely run.

Instead of lengthening station platforms and trains as was done in the New York subway, for peculiar reasons the problem was attacked in the reverse way. The cars were redesigned and converted into motor cars, and the electric locomotives thus eliminated, obtaining by this expedient more capacity per train length without the expense of lengthening the station platforms.

A still further condensation was effected by carrying the ends of 2 adjoining cars on one truck on which were the gates and platform common to both cars. The experimental train of this description was a success and at the annual meeting of the City and South London Railway on Feb. 1, 1895, it was adopted as a remedy to alleviate the crowded conditions at the rush hours.

U. S. CIVIL SERVICE COMMISSION announces an examination for laboratory aid and engineer, on Jan. 19, 1916, at principal cities of the country, to fill a vacancy at a salary of $900 a year in the forest products laboratory at Madison, Wis. At least 1 yr. practical experience with the use and care of machinery and tools, such as steam boilers, pumps, saws, electric motors, etc., is a prerequisite for consideration. A high degree of general intelligence and aptitude is required. Age, 18 yr. or over on the date of examination. Applicants must submit to the examiner on the day of the examination their photographs, taken within 2 yr. Apply for Form 1312, stating title, Laboratory Aid and Engineer (Male), to the U. S. Civil Service Commission, Washington, D. C.

Electrical Machinery and Appliances

For Generating, Transmitting and Using Current

Electrification of C. M. & St. P. Railway

REPORT OF PROGRESS ON CONSTRUCTION WORK; SUBSTATION EQUIPMENT

CONSTRUCTION work on the electrification of the western lines of the Chicago, Milwaukee & St. Paul Railway has been prosecuted most actively since the initial order for equipment was placed with the General Electric Co., in September of 1914. In view of the magnitude of this project, the progress made to date has been remarkable.

The overhead construction, which will include 650 mi. of single track, has been completed for a distance of more than 200 mi. The 100,000-v. transmission line being erected by the railway company to parallel the electrified tracks has been completed for an equal distance, and tie-in lines from the 100,000-v. system of the Montana Power Co. are ready for service. The trackage now ready for train operation includes extensive yards and sidings at Three Forks, Deer Lodge and Piedmont and passing tracks at other points. The rail bonding crews have followed the overhead construction gangs completing the ground circuits.

FIG. 1. SINGLE TRACK CURVE SHOWING OVERHEAD LINE CONSTRUCTION

Illustrations show the general appearance of the new type of trolley construction and transmission lines. It will be noted that wood-pole construction is used throughout both for cross span and bracket construction. The twin 4/0 trolley wires are suspended individually and separately from the same steel catenary and the hangers of one trolley wire are located at points mid-span on the other. In the switching yards only one trolley wire is used.

SUBSTATIONS

SEVEN SUBSTATIONS, designed to supply power to the first half of the 440 mi. of route, have been completed, and electrical equipment is being rapidly installed. Complete shipments of transformers, motor-generator sets, switchboards and other accessories, have been made by the manufacturers for the stations first erected, and the equipment of 4 substations is practically ready for operation. Construction crews are proceeding with the erection of the remaining 7 substations between Deer Lodge, Mont., and Avery, Ida.

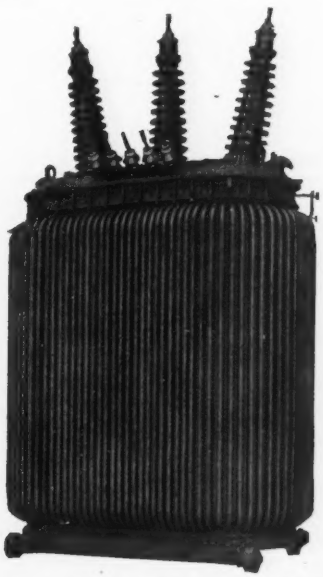


FIG. 2. RADIATOR TYPE, 1900-KV.A., 100,000-V. TRANSFORMER

Each of the motor-generator sets consists of a 60-cycle, 3-phase, 2300-v., synchronous motor direct-connected to 2 1500-v., direct-current generators. The generators are connected permanently in series to supply 3000 v. to the trolley. Each set is also provided with an exciter at each end, one providing excitation for the revolving field of the motor and the other supplying the separately excited fields of the direct-current machines.

These sets are in general similar to the 5 1000-kw., 2400-v. units in operation on the Butte, Anaconda & Pacific Railway, except as regards voltage and capacity. One new feature, however, has been added which deserves mention. This consists of a longitudinal ventilation of the core and field coils similar to that employed in the well-known GE ventilated railway motor. The use of this method of cooling has effected a considerable reduction in the floor space required per kilowatt.

The direct-current generators are equipped with commutating poles and compensated pole face windings to insure sparkless commutation under heavy overloads. This overload capacity is 150 per cent normal load for 2 hr. and 300 per cent normal load for periods of 5 min. This will provide ample margin for starting a train of maximum tonnage on the most difficult grades.

It is interesting to note in connection with these substations that the motor-generator sets are designed to operate inverted in case the regenerated power exceeds

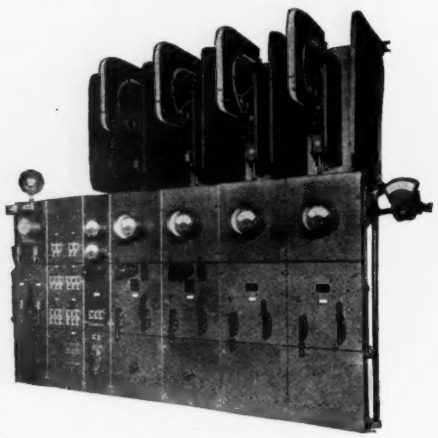


FIG. 3. HIGH-VOLTAGE DIRECT-CURRENT SWITCHBOARD

that required by other trains operating nearby. For this reason, there is no necessity for water boxes or other energy consuming devices, since the excess energy is transmitted to the 100,000-v. system.

Switchboards

THE MAIN direct-current switchboard in each station is of special interest, since it represents the latest practice in high voltage direct-current switching apparatus. A panel is provided for each set and 2 panels are provided for feeders in each direction.

The circuit breakers and switches are mounted on separate panels located above and a short distance back of the main panels, similar to those now operating in the Butte, Anaconda & Pacific substations. The control handles for operating the breakers and switches are located on the main panels and are connected to the circuit breaker panels through insulated wooden rods.

In addition to the special high-voltage, direct-current panels, switchboards are also being furnished for the synchronous motors and auxiliary circuits. Oil switches and other standard 100,000-v. equipment are also being installed for the high tension circuits.

Transformers

THE TRANSFORMERS, which are under construction, are an example of the most recent design. There are a total of 32 of these units which are to be used for stepping down the power supply from the 100,000-v. transmission line to 2300-v. as required for the synchronous motor-generator sets. These transformers will be installed in 14 substations, which will furnish power for the entire electrification from Harlowton, Mont., to Avery, Ida. There are 23 2500-kv.a. and 9 1900-kv.a. units.

These transformers are all of the 3-phase core-type with a ratio of voltages of 102,000 to 2300. For regulating purposes, taps are provided for 97,200 v. and 94,200 v. Taps are also brought out on the secondary windings to give 1150 v., or half voltage for starting the motor-generator sets.

The transformers are oil cooled and the tanks are of the tubular type, the main body consisting of steel plate with tubes welded to the side of the tank at the top and bottom, giving absolutely oil-tight joints. An air drier and breather is attached to the tank so that all interchange of air between the interior of the tank and the outside must take place through this channel. This drier is provided with chambers containing a moisture extracting medium, thereby preventing the entrance of moisture to the tank.

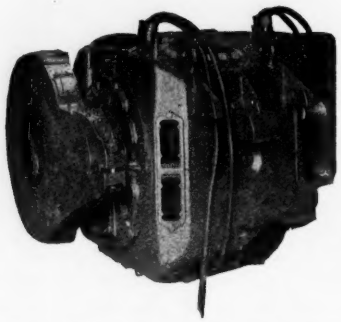


FIG. 4. 430-HP., 3000-V. DIRECT-CURRENT RAILWAY MOTOR

The bushings furnished with these transformers are weather-proof, and as all joints are tight, they are suitable for outdoor as well as indoor operation. At the top of the high-tension oil-filled leads is a glass cup which shows the height of oil in the leads. Accessories consisting of thermometer, oil gage and drain valve are also provided. Each transformer is mounted on flat wheels to facilitate movement for making repairs and a lifting device is furnished for removing the transformer core.

Auxiliary Transformers

IN ADDITION to the main transformer equipment, each substation will be furnished with a standard 10-kw., 3-phase transformer stepping down from 2300 to 110 v. for lighting and auxiliary power circuits.

For operating the railway signal circuits, a standard 25-kw., single-phase transformer is being installed in each substation stepping up from 2300 to 4400 v. A portable oil-drying outfit will be used for removing moisture from the transformer oil. This outfit consists of a motor-driven pump which forces the oil through an especially designed filter and the electric drying oven for drying the filter paper. A portable transformer dryer and an oil testing set will also be supplied.

Locomotives

Work on the construction of the 42 282-ton locomotives for this electrification is progressing rapidly at the Erie Works of the General Electric Co., and the Schenectady plant of the American Locomotive Co. The first complete locomotive was placed on the test tracks early in September and shipment was made as scheduled on Sept. 25. This locomotive has been taken in charge by the railway company at Chicago and is now being exhibited at various points on the Chicago, Milwaukee & St. Paul system. A complete set of tests indicate that the locomotive will easily exceed the expectations of the designers.

Twelve of the locomotives on order are geared for passenger service and the remaining 30 are geared for freight service. Both freight and passenger types are equipped for regenerative braking, this apparatus being under control of the engineer. All of the passenger locomotives and several of the freight locomotives will be equipped with oil-fired steam boilers for heating the passenger trains. This equipment will include ample storage tanks for oil and water.

Watthour Meters*

Meter Constants and Care of Instruments. By O. H. Henschel

MANY constants are employed in watt-hour meters, such as the dial constant, watt-hour constant, watt-minute constant, watt-second constant and testing constant. Dials found on the registering mechanism are generally of the 4 or 5-cycle types, the various divisions of which represent decimal parts of kilowatt-hours, kilowatt-hours, 10 kw.-hr., 100-kw.-hr., and so on, depending upon the number of circles employed and the size of the meter. In the early and especially in high-capacity types, each division of the first or right-hand dial, when facing the meter, represents 0.1 kw.-hr., so that one complete revolution of the hand on this dial represents 1 kw.-hr. In a similar manner, one revolution of the following dial hands represents 10, 100, 1000 kw.-hr., etc.

Watt-hour-meter dials may be direct reading or indirect reading. The former are those requiring no multiplier to give the proper reading, while indirect reading dials are those that do require a multiplier to give the proper indication of the units passing through the measuring system. In the earlier forms of meters, it was customary to keep the register ratio constant for almost all capacities. The register ratio just mentioned is the term given to the ratio between the first gear of the ratio gears and the first pointer, and means the number of revolutions of the first ratio gear or gear meshing into the worm on the shaft of the rotating element, necessary to cause one complete revolution of the first pointer.

In order then to record properly the units of energy passing, it is necessary to correct the dial reading by multiplying the reading by a multiplier or constant. These constants may have any value from ¼ to 1000, meaning that in order to obtain the actual amount of energy flow, it is necessary to multiply the difference between 2 successive meter readings by the required constant, usually found marked on the face of the dial.

The present tendency in meter design and construction is, however, to eliminate the use of dial constants and thereby avoid much confusion. With meters employing no dial constant or, to be more correct, having a constant of 1, the actual energy measured is that obtained by taking the difference between 2 successive meter readings.

Every revolution of the rotating element, when the meter is correctly calibrated, must record on the register a definite amount of energy. This may be, for example, 1 w.-hr. or 0.25 w.-hr., in which case the so-called watt-hour constants would be 1 and 0.25 respectively. This constant is determined by the meter manufacturers and varies with the type and capacity of the instrument. Up to the present time, no standards for meter constants are employed.

The watt-hour constant is the value of one revolution of the disk in watt-minutes and since there are 60 min. in 1 hr., this constant can be obtained by multiplying the watt-hour constant by 60. In a like manner, the watt-second constant is the value in watt-seconds of 1 revolution of the revolving element and may be obtained by multiplying the watt-hour constant by 3600, or the watt-minute constant by 60.

The calibrating constant is used exclusively for testing purposes and while in some cases it is identical with the watt-hour, watt-minute or watt-second constant in other instances, it is entirely different from these. This constant is usually designated by the letter K or C and may be found marked on the disk or cup or in instruction books furnished with the meter, as $K = 0.25$, or $C = 1.0$. The use of this constant is taken up under Testing, which follows.

Cleaning Meters

Regardless of precautions taken by meter manufacturers to make their instruments dust proof, more or less of this will find its way into the casing, and if not removed will seriously interfere with the proper operation of the meter. In addition attention should be given to blackened commutators and brushes, sluggishness of the registering mechanism and sticky or damaged jewels and top bearings.

After opening a meter, a good plan to follow is first to remove the jewel, trying this out by means of a sharp pointed instrument or needle, going carefully over its working surface to detect any possible roughness. If such exists, the jewel should be discarded and replaced by a new one. If desired, the bearing end of the shaft may be given a little lubricant by dipping the end into a bottle of jewelers' oil and upon taking it out, carefully wiping off all surplus oil. This part of a meter requires but little lubrication.

Next examine the top bearing. If it shows any wear, replace it with a new one.

If the meter in question is of the commutator type, put on full load, carefully watching the behavior of the brushes and commutator. If these are rough and black-

*Continued from page 1086, Dec. 1 issue.

ened and spark badly, file the brushes first with a fine file, following this with sandpaper of the finest grade obtainable. Then by means of a special and fine grade of emery cloth, cut into strips having widths the same as that of the commutator, remove all deposit by passing one of the strips around the commutator, whirling it by drawing the cloth back and forth. When all the black deposit has been removed, turn the strip of cloth, bringing the soft side next to the commutator and repeat the whirling so as to give it a highly polished surface.

Look carefully between the damping magnets and disks, as particles of dust, dirt and iron have a tendency to adhere to the inner surfaces of the magnet poles, causing a serious drag on the disk with consequent slowing down of the meter.

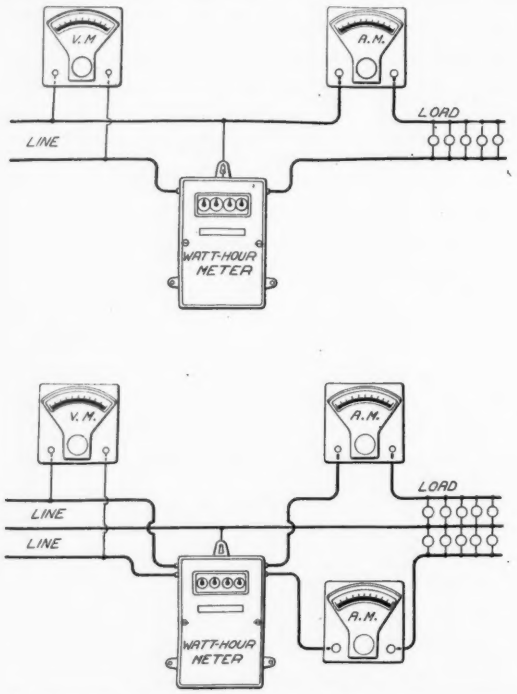


FIG. 8. CONNECTIONS FOR TESTING WATT-HOUR METERS BY THE AMMETER-VOLTMETER METHOD

After this has been done, it is good policy to blow out all inaccessible parts with compressed air at a low pressure.

The registering mechanism may then be removed. Before doing this, however, carefully note the reading of the hands so that these may be correctly reset when replacing this part of the instrument.

To remove any dirt, grit or gum which may be lodged between the various gears, their shafts and bearings, place the whole element in a small tray of gasoline, letting the parts soak well, and at the same time operating the mechanism by hand, so that the gasoline will find its way to all parts of the system of gearing and thus remove as much dirt and grit as possible. Upon removing the register from the gasoline, lay it aside to dry, after which oil the various bearings with a high grade of jewelers' oil applied by dipping a sharp pointed tool into the oil and placing but one small drop on each bearing.

TESTING

WATT-HOUR METERS may be checked by the use of the volt-ammeter method, an indicating wattmeter, or by the employment of a standard watt-hour meter, generally known as a rotating standard. The method used depends entirely upon the nature of the circuit. As a rule, all direct-current instruments may quite readily be tested by checking their performance with the readings of a volt-meter and an ammeter connected up for that purpose. Indicating watt-meters or some direct-current type of rotating standard may also be used. Due, however, to the introduction of power factors less than unity, it is always advisable to use some reliable indicating watt-meter or rotating standard in the testing of alternating-current watt-hour meters.

In either alternating or direct-current work, if the load on the meter is not absolutely steady, rotating standards must be used, if any degree of accuracy is desired.

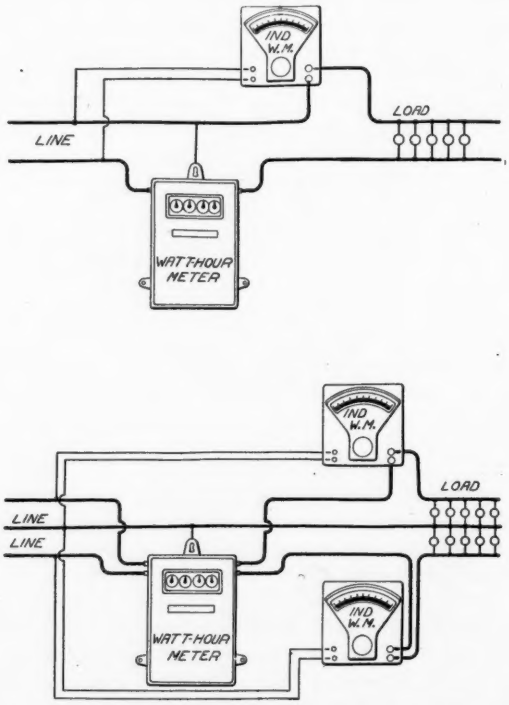


FIG. 9. CONNECTIONS FOR TESTING WATT-HOUR METERS BY THE INDICATING WATTMETER METHOD

Under the subject of Constants, mention was made and an explanation given of watt-hour, watt-minute, watt-second and testing or calibrating constant. The testing or calibrating constant, a value assigned to different meters by the manufacturer, to be used when calibrating the instrument, and which may or may not be the same as the watt-hour, watt-minute or watt-second constant, is usually found marked on the disk or cup or printed on the instructions accompanying the meter. If the calibrating constant is known in terms of watt-hours per revolution, it is comparatively easy to determine the accuracy of the meter.

If the calibrating constant in terms of the watt-hour constant is known and represented by the letter *K* and

the time in seconds determined for the meter to complete R revolutions, the watts may be found by dividing the product of 3600 times R times K by the number of seconds required to complete R revolutions. The constant 3600 is introduced to reduce the watt-hour constant to a watt-second constant on account of having obtained the time in seconds, which, for accuracy, should always be done by means of a stop watch.

As an example of the above, let us assume having a meter the calibrating constant of which is 0.5 expressed in watt-hours, and which required 40 sec. to complete 10 revolutions. Dividing the product of 3600 times 10 times 0.5 by 40, we obtain 450 as the number of watts.

Should the calibrating constant be expressed in terms of the watt-minute constant, the number of watts is equal to the product of R times K divided by M, where R is the number of revolutions of the rotating element, K the calibrating constant in watt-minutes and M the number of minutes.

Some meter manufacturers employ a calibrating constant expressed in terms of 1/100 of the watt-second constant; in other words, C, or the calibrating constant, times 100 is the watt-second constant. Under such conditions, the number of watts is equal to the product of C times 100 times R divided by the number of seconds required to make R revolutions; in which case, C is as just explained and R is as above, the number of revolutions completed by the rotor within the time noted. The value of C when so used can also be expressed as the number of seconds required for the rotating element to make 100 revolutions.

Having determined the number of watts registered by the meter by any one of the above rules and the number of watts registered by a rotating standard, or obtained from the product of voltmeter and ammeter readings, the accuracy of the meter may readily be obtained by dividing the meter watts by the standard watts, the quotient of which when multiplied by 100 will give the per cent accuracy.

For testing 2-wire direct-current or single-phase alternating-current meters at unity power factor and under absolutely constant load conditions, by means of the volt-ammeter method, connect the various instruments as shown in Fig. 8. Having adjusted the load to the desired value, being careful to maintain a constant flow of current under a constant voltage, allow the instruments to remain under this load for a period of from 5 to 10 min., so as to warm up the working parts. With the desired load on the meter, time a given number of revolutions of its rotor by means of a stop watch, noting the number of seconds required.

The number of watts registered by the meter under test will then be equal to the product of 3600 times the calibrating constant, expressed in watt-hours, times the number of revolutions of the rotor divided by the number of seconds required. The standard watts are obtained by multiplying the voltmeter reading by the ammeter reading. Dividing the meter watts by the standard watts and multiplying the quotient by 100 will give the per cent accuracy.

This same test may be conducted by using an indicating wattmeter instead of the volt and ammeter, a method to be preferred, as it eliminates, to some extent, the personal and instrumental errors introduced by the use of 2 instruments.

It should be noted that the ammeter-voltmeter method can only be used when the load is held at a constant value. When employed with single-phase, alternating-current meters, it is essential that the power factor be unity. If such is not the case, the product of the ammeter and voltmeter readings will be the apparent number of watts and not the real number.

When testing 3-wire direct-current meters, it is necessary to use 2 ammeters instead of one, the total number of amperes being equal to the sum of the readings of the 2 ammeters.

In the wattmeter method of testing 3-wire direct-current watt-hour meters, it is also necessary to have 2 wattmeters instead of one.

When using certain types of indicating wattmeters on direct-current circuits, the wattmeter method of testing is open to serious objections, due to the fact that these instruments, being designed for use on alternating-current circuits, are affected to a considerable extent by the earth's magnetism and other stray magnetic fields. This error may, however, be eliminated by taking 2 readings under like load and pressure conditions, the second to be taken with series and potential coil connections reversed. The average of these 2 readings will give the correct number of watts.

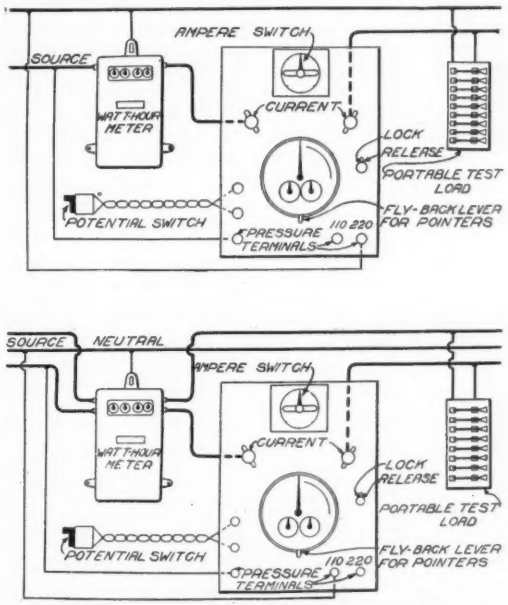


FIG. 10. CONNECTIONS FOR TESTING WATT-HOUR METERS BY THE ROTATING STANDARD METHOD

For both direct and alternating-current meter testing, the most accurate and reliable results are obtained by the use of the portable rotating standard. The principle of operation of this instrument, made in both direct and alternating-current types, is the same as that of any watt-hour meter, although its construction is somewhat different to meet certain requirements. This type of instrument must be of a portable form which may be easily carried about; it must have a wide range

of current carrying capacities in order that it may be used in measuring full and light loads accurately and in testing meters of different capacities; and it must have an easy and reliable means of determining the number of revolutions of the rotating element.

Various methods of connecting rotating standards are employed, the diagram in Fig. 10 illustrating that used in testing either 2-wire direct-current or single-phase alternating-current meters.

With the proper connections completed, the watt-hours as indicated by the meter under test are compared with the watt-hours as indicated by the portable rotating standard. The desired load is placed upon the meter under test and at a given instant by means of a switch provided for the purpose, and generally controlling the potential circuit, the portable rotating standard is set in motion during a given number of revolutions of the meter under test. The number of revolutions of the meter under test is then compared with the number of revolutions made by the standard during the same period, obtained by taking the difference in dial readings of the standard at the beginning and end of test. Knowing the calibrating constants of both test and service meters and their respective speeds, the percentage of accuracy of the service meter may be found by multiplying the quotient of (the product of the watt-hour constant of the meter under test by the counted revolutions of that meter) divided by (the product of the watt-hour constant of the standard times its counted number of revolutions) by 100, or per cent accuracy = $(K_1 \times R_1) \div (K_2 \times R_2) \times 100$, where K_1 is the watt-hour constant of the meter under test, R_1 the counted number of revolutions of the meter under test, K_2 the watt-hour constant of the standard, and R_2 its counted number of revolutions.

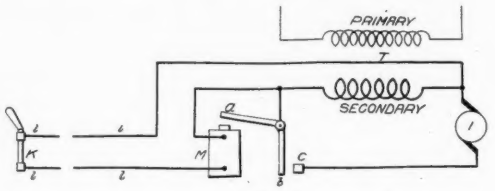
The various types and makes of polyphase watt-hour meters call for various schemes of connections for testing, diagrams of which are always willingly furnished by the manufacturers.

(To be continued.)

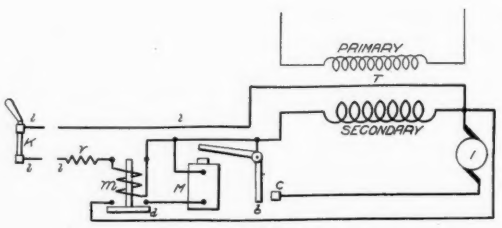
Too Much Line Drop

By E. C. Parham

In Fig. 1 are shown the connections used for starting an alternating-current motor by means of a switch located at some distance. Closing of remote-control switch, *K*, energizes contactor operating-coil *M* from transformer *T*. The downward movement of armature *a* causes contacts *b* and *c* to complete the circuit of motor *I*, which also depends upon transformer *T* for energy. Under average conditions, this arrangement gives satisfaction and by using a special contactor coil, the distance through which such an arrangement can be operated is increased. Line drop in push-button circuit *l-l* limits the distance, as illustrated by the following incident. A mining operator bought a remote-control panel for a 3-phase induction motor. As long as the outfit was applied to the duty originally assigned to it, operation was entirely satisfactory. The operator at a later day complained that the closing of switch *K* failed to close the contactor and, thinking that coil *M* might be weak from age, installed a new one, which, however, did not help matters. It developed that the operator had changed the location of the motor and the panel by moving them 5 miles up in the mountains while remote-control switch *K* was retained in the office. To make the outfit operative under this condition, a relay *m-d*, as shown in Fig. 2, was installed. The push-button transmission current then had to operate only the relay plunger *d*. Upward movement of the relay closed the local circuit through the relay contacts, the contactor operating-coil *M* and transformer *T*. Closing of the contactor started the motor as in the first case.



F16.1



F16.2

FIG. 1. REMOTE CONTROL AS ORIGINALLY INSTALLED
FIG. 2. ARRANGEMENT EMPLOYED TO CONTROL MOTOR AFTER BEING MOVED TO NEW LOCATION

In Fig. 2, the switch indicated conventionally by K, is opened by pushing on one button, and is closed by pushing on another button; sometimes a knife switch is used instead of a push button. As long as the switch is closed, the circuit of the relay coil is energized and the relay disk, d, is up; as long as d is up, the circuit through the contactor operating coil, M, is closed and the contactor finger keeps the motor circuit closed. Opening *K* by hand opens all circuits and stops the motor.

The Westinghouse Electric & Mfg. Co. announces the following more important among the larger number of awards received at the Panama-Pacific Exposition.

The Grand Prize, the highest possible award, on the 4000-hp., 650-v., d.c. double unit Pennsylvania electric locomotive mounted on a turntable under the dome of the Transportation Palace. The Medal of Honor on alternating-current and direct-current industrial motors and control apparatus, on precision instruments, on Le Blanc condensers, on motor-generator sets for moving picture machines and on high voltage oil switches. The Gold Medal on a number of different classes of apparatus among which are steam turbines, alternating and direct-current generators, alternating and direct-current railway motors, transformers, rectifiers, starting lighting and ignition systems, switchboards and accessories, and mining locomotives, also the Gold Medal for the most complete and attractive installation in the Palace of Transportation.

Reinforcements for Manhole and Stock Openings

By C. J. Craffey

THE old saw regarding the weakest link in the chain applies forcibly to boiler construction, for though the thickness of plates may be carefully calculated, the efficiency of seams determined to 3 decimal places, the number of braces figured to a nicety and the whole structure supported in the most approved manner, yet an apparently unimportant opening into the shell or head may prove the determining factor in the finished vessel simply because proper reinforcement had not been given to the opening to make it equal in strength to the other parts.

Briefly stated, an opening in a plate should by reinforcement, be equal in strength to the solid plate. To replace the stock necessary for proper reinforcement, requires calculations that are often neglected. It is not unusual to find in certain types of drum boilers, no reinforcement whatever at the manhole opening in head. The same condition prevails when a manhole is placed in a dome head. In the better designed drum boilers the opening in the head is strengthened as shown in Fig. 1. The ring, which is shrunk on the manhole flange and then doweled, has a net cross-sectional area at least equal to the area of metal removed along the greatest diameter of opening. The ring, in addition to strengthening the opening gives a good bearing surface for the

FIG. 1. REINFORCEMENT FOR MANHOLE IN DISHED HEAD

gasket. A manhole opening in a plate may be reinforced with one of several designs of manhole frames, the most modern of these being the pressed steel ring, shown in Fig. 2. The old style cast-iron frames are notoriously weak, and even with the steel rings cases of insufficient reinforcement are by no means uncommon.

As a rule, there is no need of reinforcing a small opening like a water column connection; but any opening in a shell or head 2 in. diameter or over should be strengthened. In the following illustration, the method of figuring a manhole ring is given and the principle is applicable to other forms of openings. The cutout in the shell of a horizontal return tubular boiler is 16.5 by 22.5 in. The shell plate is 0.5 in. thick and has a tensile strength of 57,000 lb. per sq. in. An 11 by 15-in. pressed steel manhole frame is to be used, tensile strength not less than 52,000 lb. per sq. in., and $\frac{5}{8}$ in. bearing surface for the gasket. Determine the width of ring and number of rivets necessary.

From our knowledge of the relative strength of a cylinder longitudinally and girthwise, we at once decide to place our opening so that the shortest diameter of the ellipse will be in a plane parallel to the length of the boiler; that is, the least amount of stock is removed along the weakest line. The total strength of the material removed along the longitudinal line is then,

$$16.5 \times 0.5 \times 57{,}000 = 470{,}250 \text{ lb.}$$

Dividing this by the tensile strength of the ring we have,

$$470{,}250 \div 52{,}000 = 9.043 \text{ sq. in.}$$

equals the net area required in the ring along the short axis, and the area through one side would be,

$$9.043 \div 2 = 4.5215 \text{ sq. in.}$$

The thickness is determined by the bearing surface for gasket, so the net width of the ring will be,

$$4.5215 \div 0.625 = 7.234 \text{ in.}$$

There is, however, a rivet hole taken out of the ring along the weakest element, and to compensate for this, the width must be increased by the diameter of the rivet hole. If we use a 15/16-in. hole, the total width of the ring would then be,

$$7.234 + 0.9375 = 8.171 \text{ in.}$$

Considering now the number of rivets necessary we find that a 15/16-in. rivet in single shear, with a shearing value of 48,000 lb. per sq. in. cross-sectional area

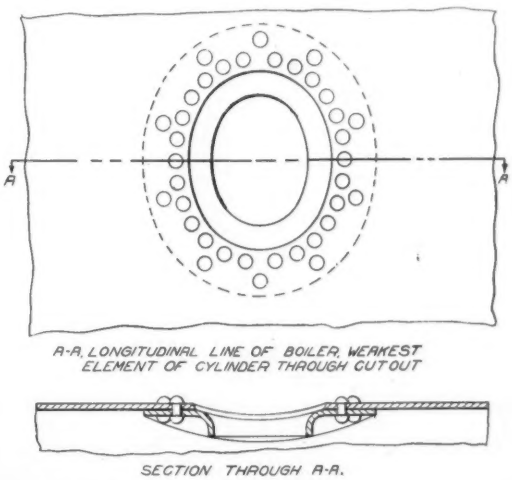


FIG. 2. MANHOLE REINFORCED BY PRESSED STEEL RING

has a shearing strength of 28,993 lb. The number of rivets necessary to equal the strength of plate removed is then,

$$470{,}250 \div 28{,}993 = 16.2 \text{ rivets.}$$

In practice, 17 rivets would be used, arranged in 2 rows as shown in Fig. 2. It will be noted that the rivets are arranged 17 each side of center line and 2 rivets in center line. The 2 latter rivets are not in shear when failure along the weakest element is considered.

In paper mill work there is found a type of boiler known as the rotary bleach boiler. Their purpose is to cook or bleach wood chips or rags under steam pressure. During the cooking process, the boiler revolves slowly about its longitudinal axis, the stock being tumbled about by means of radial pins attached to the shell of the rotary. Large stock openings are necessary to facilitate loading and unloading. After cooking is completed, the charge is drawn with long handle rakes, and by having the long axis of the stock opening parallel

to the longitudinal axis of the cylinder the charge is more quickly and thoroughly removed. Stock openings vary greatly in size, the long axis of the ellipse being in some cases as great as 54 in. Heavy reinforcement is therefore necessary to compensate for the stock removed and, as there is an additional strain caused by the stock pounding as it is tumbled about, from 15 to 20 per cent excess metal in the rings is advisable. A glance at Fig. 3 shows that the long edge of the opening

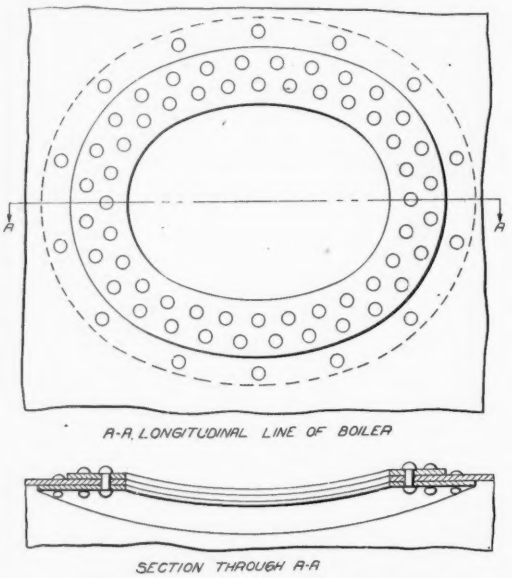


FIG. 3. REINFORCEMENT FOR MANHOLE IN SHELL OF ROTARY BOILER

forms practically a longitudinal seam. A frame similar to that in Fig. 2 should not be used for a stock opening, since it would form a longitudinal seam with an efficiency of about 60 per cent. In Fig. 3 is shown an acceptable method of reinforcing a stock opening, making a triple riveted seam with inside and outside strap at the long edge. The rings should be calked at each edge adjacent to a narrow pitch and sufficient bearing should be allowed between the edge of opening and rivets for cover plate.

Beyond Belief

THE TROUBLE MAN GETS SOME REAL LIFE SIZE EXPERIENCE. BY TRAVELER

TING-a-ling-a-ling, ting-a-ling-a-ling, ting-r-r-r-r. Being a trouble shooter, I live pretty close to the telephone, whether at home or traveling, and invariably, though I much dislike the noise it makes, I get the receiver to my ear before central has stopped ringing, and am half deafened by the vibrating disk in the receiver.

"Hello, hel-lo!" I yelled into the transmitter and was greeted by a string of words from an excited engineer, only a portion of which were audible; but I managed to find out that it was the central station that was in trouble, the engine refusing to run.

Having been in this small Missouri River town on other business for a few days, my reputation as a power plant doctor had spread among the few engineers in the place farther than I knew and I was compelled to inquire of the hotel clerk and the one policeman before I could locate the plant; so it was 10 p. m. when I first gazed on what the village was wont to call a central station,—out of courtesy, I presume, as the owner was the mayor of the town and proprietor of the leading general merchandise store.

How such a collection of machinery could be run at all was a puzzle to me. The building was a ramshackle affair which had once been a store room, having a basement the same size as the engine room. The floor at this time consisted of 2-in. boards laid loosely on the joists, with holes all the way from the size of your foot to large enough to let a boiler fall through, and never a railing in sight.

The outfit consisted of what had once been a good 600-kw. turbine unit, the condenser of which now kept you guessing whether it would stay on the foundation or go through the wall, being set, as it were, on stilts. The other unit was an old Corliss engine built, perhaps, about 1887 or earlier, with a cylinder 24 by 42 in., and a 16-ft. flywheel. This engine was belted tandem to 2 1000-v. generators, one belt being run on top of the other.

The generators were of the revolving field type, about the same age as the engine. This engine, when it ran, was run noncondensing, but just now it refused to budge, either condensing or non-, hence I was most urgently invited to give it my attention.

After looking over the "old gal" carefully, I decided to try her out; it was then past midnight and the load was down to near 100 kw. The boiler room? Oh yes, there was one; but there was no report of trouble from that source, so I did not look into it, much to my regret later on.

We used a telegraph pole to pry the engine off center, then opened the throttle a little. The engine rolled over just like a trained donkey in a circus, so we got it up to speed. Everything seemed all right, except the crank-end steam valve which failed to hook up part of the time, and I began to strut around that engine like a buff cochin cockerel when he sees the season's first hatching of chicks. Perhaps my attitude was too much for the regular men about the plant; at any rate, when I stepped to the front of the engine some one of the many engineers, firemen, electricians or perhaps it was the mayor himself, threw the load on the engine, at the same time cutting out the turbine.

Things happened good and plenty, and were not slow in doing it, either. The crank end now would not hook up at all, the lights went down, the man at the switchboard threw off the load, leaving the station in total darkness; the old engine, freed from her load, started out to show us what she could do, and the way she went would make Joe Patchen, Jr., turn black in the face with envy.

Imagine, if you can, my predicament, a stranger in a strange land at the mercy of a worse than strange engine, doing its best to wreck a 16-ft. flywheel. I had no faith in the governor; in fact, I had no faith in anything. Between me and the throttle were holes galore, large enough for a man twice my size to fall through, and whether the water in the basement was deep enough

to drown me I had no means of knowing, nor did I care to find out by trying. There was about 8 in. of floor between the throttle side of the cylinder and the now flying belts; it was worth more than my life insurance to try to reach the throttle, so I crept along the guides until I could get hold of the governor, which I seized in a vise-like grip and yelled right lustily for someone to shut off the steam at the header.

Engineers and electricians, if by reason of their connection with the plant we can call them such, had fled at the first sign of darkness.

Fortunately for me, there was a freckled faced kid in the boiler room, who, with more curiosity than discretion, was waiting to see what was going to happen, and had gumption enough to open the furnace doors, giving him sufficient light to see to close the valve.

After things quieted down, the denizens of the place wandered in one by one,—they had been looking for a light, I presume, at least one of them had a lantern. While it did not give much light, it was enough to discover that the only exciter unit in the house was motor driven and was now useless—current had ceased to excite in that place. Finally, we found a small generator which we carried over and belted to the flywheel of the air pump and got the turbine unit into commission again.

Up to this time, I believed myself in a nightmare. I could not run, I could not see, I could scarcely yell; but when the lights came on, the stern reality of the situation was plainly evident. The fields of the generator next the engine had been thrown out so that they struck the armature, which threw the under belt off, which in turn wrapped under the other belt and pulled the second generator off the foundation. The engine frame was broken just back of the guides, the valve gear was utterly destroyed; the outboard bearing had danced a jig all over its foundation.

It was at about this time I concluded to take a look at the boiler room. They had just put in new water-tube boilers, and we had turned 180 lb. of steam into an old engine which was not built for more than 85 at most; no wonder she got dizzy. That someone was not killed and the place entirely wrecked, was due more to a kind Providence which looks out for fools and babies, than to our own management or sense.

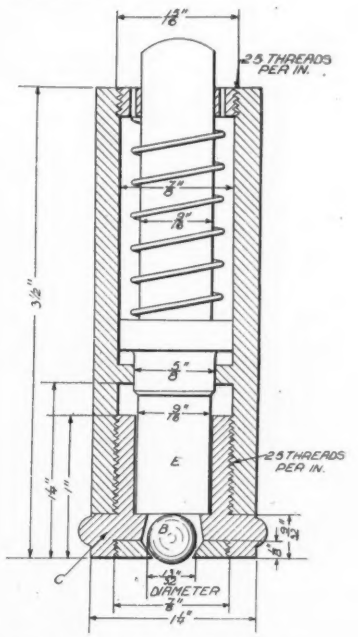
Foreign Development in the Power Plant Field

Hand Tool For Testing Hardness of Metal. By J. H. Blakey

IT is often desirable to make a quick test of the hardness of a metal, without going to the trouble of a carefully conducted experiment; in many cases, it may be useful to make an approximate determination in order to calculate the highest allowable cutting speed for a machine tool. Such a test may be easily made by the workman with the hand apparatus shown in the accompanying drawing taken from Le Reveu de Metallurgie.

The principle of the test is to drive a ball of hardened steel simultaneously into the metal under test and into a standard piece of known hardness by means of a blow from a hammer. A little consideration will make it apparent that when the head of the shaft, P, is struck a sharp blow, the area of the indentations produced in the metal to be tested and in the standard, E, will be inversely proportional to the respective hardnesses; that is to say, the smaller the indentation the greater the hardness. To put the relation into a mathematical formula, if H is the Brinell hardness numeral for the standard piece, E, which is known, and h that of the metal to be tested, and D and d the areas of the impressions made in standard and metal respectively, we have H is to h as d^2 is to D^2 or h equals HD^2 divided by d.

This formula is not absolutely correct, as the precise relation is given by comparing the areas of the 2 concave surfaces of the indentations, and these are not exactly proportional to the squares of the diameters of the circles; but for all practical purposes, it is near enough in all cases in which the diameter of the impression is less than 0.25 in. In other cases, the numbers found diminished by 10 will give the true Brinell hardness numeral.



SECTIONAL VIEW OF HAND TOOL FOR TESTING HARDNESS OF METALS

The standard is a piece of round steel which has been thoroughly annealed in order to insure perfect homogeneity. If it is practicable to have it tested to determine its hardness numeral, the above formula is used; if, however, the tensile strength only is known, the required hardness numeral is given by the formula h equals T divided by 4.8, T being tensile strength in pounds per square inch.

The dimensions on the accompanying drawing give a size of the apparatus such as is in use in France, and will probably be suitable for all purposes. As the standard piece, E, has to be changed end for end or replaced after each test, the nut, C, and its socket are made with an interrupted thread, similar to that of the breech block in a breech loading gun, so that the change can be made very quickly.

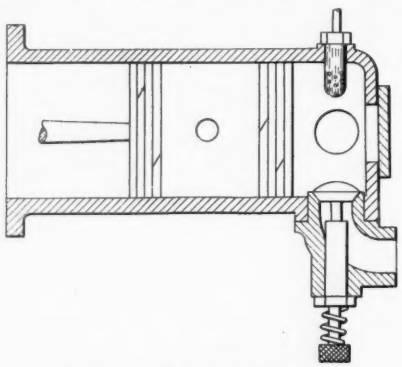
GAS POWER APPARATUS

Producers, Engines and Industrial Applications

Development of Crude Oil Engines

MISCELLANEOUS SYSTEMS. BY SAMUEL M. HOWELL

FEEDING a small quantity of water into the cylinder of an oil engine has long been advocated, and is now a recognized custom. The principal object of the practice is to prevent the formation of carbon deposits on the interior surfaces of the combustion chamber, and thereby avoid the occurrence of pre-ignition, and its attendant annoyances; and it also permits the use of a higher compression than could otherwise be employed, and in this way adds somewhat to the output of power, or effects a corresponding reduction in the quantity of fuel used. It is well known that many oil engines, when operating without the injection of water, will accumulate deposits of carbon within the cylinder, and these, becoming highly heated in the burning gases, prefire the charge upon the following compression stroke.



HOPKINSON COOLING SYSTEM

This unconsumed carbon results from a slight imperfection in the process of combustion, and this always occurs in the burning of oil or gas under any but the most favorable conditions. The hydrogen of these oil fuels may be entirely consumed, but the carbon element is more resisting, and will not burn completely under ordinary circumstances. The high temperature required for its full combustion is not always present in the cylinder of an oil engine using only a moderate degree of compression, and a portion of the unburnt carbon is precipitated upon the walls of the combustion space. In the presence of water vapor, however, this action does not so frequently occur, the fuel appearing to be more completely consumed. The highly heated steam from the water is decomposed, and the 2 elements, that is, the oxygen of the water and the deposed carbon of the fuel, thus meeting in a nascent condition, instantly unite and no free carbon remains. It is true, too, that the water somewhat reduces the temperature of the metal parts just prior to the moment of ignition, and this is of further benefit in the operation of the engine; but another important effect is that the steam from the water dilutes the mixture, and reduces the rate of flame propagation; this action is also beneficial for the reason that this rate of burning is otherwise too rapid. It is well known in the general science of this subject that there is a great loss of useful effect when the rate of combustion is too greatly in excess of the piston speed of the engine, and therefore the use of water in this way may increase the output of power.

THE HOPKINSON METHOD OF COOLING

TO CARRY the practice of water injection a step further and cool the cylinder by this means alone is an obvious proceeding, and has been an attractive proposition to a number of inventors; but the application of the principle presents some difficulties, and has not hitherto been successful.

It is said, however, that Professor Hopkinson, of an English University, has recently devised a method by which the cooling is effected by the injection of water in a single walled cylinder, without the use of either jacket or radiating ribs. His device consists of a quick acting pump of small size, and a nozzle terminating in a bulb within the combustion space of the engine cylinder. The bulb is perforated with a considerable number of very small holes, and is so located that the water as it issues from these holes is thrown directly upon the face of the piston, the exhaust valve, and all the internal surfaces of the combustion space (see illustration). The water is injected while the crank is turning the center, at the beginning of the power stroke, commencing 30 deg. before the center, and ending at the same angle thereafter, and is coincident with the burning of the fuel, and the development of greatest heat. The quantity of water used is about 2.5 lb. per hp. per hr. The success of the method arises from the fact that the water passes through the burning charge and strikes the metal surfaces in a liquid condition, cooling them to the necessary extent without seriously reducing the temperature of the flame. The nozzle is designed to deliver the water in particles of small size, of course, but yet in solid form, and any means by which the water would be atomized or reduced to a state of extremely fine division is especially avoided; as water thus delivered would evaporate while passing through the flame, and by abstracting the heat would curtail the development of

power, and fail at last to moderate the temperature of the cylinder walls. It is understood, of course, that the pressure is a direct result of the heat of the burning charge, and to reduce the intensity of this heat is to lower the pressure, and modify the useful effect of combustion; and herein lies the chief cause of many former failures; but another important point in the application of this method is the time at which the water is supplied. It is usually assumed that ⅓ of the heat developed in the cylinder is absorbed by the metal, and must be carried off through the jacket; and it is said to have been demonstrated that as much as 80 per cent of this heat is received by the face of the piston and the walls of the combustion space during the first quarter of the power stroke. If this be true it is evident that the injection of the water may cease at an early period in the power stroke, as this surplus heat will then have been taken by the water, and that afterward received by the metal from the expanding charge is relatively small, and may safely be absorbed by the cylinder walls, and dispersed in the atmosphere.

The direct cooling of the piston by this method is also a point of considerable advantage, and another feature of some value is the fact that the steam thus generated at the beginning of the power stroke adds volume to the expanding gases, and is produced without cost from a portion of the heat which must otherwise have been lost.

Engines of this character and of very large size have been constructed and operated for more than a year, now, with entire success. In order to guard against trouble which might be caused by a temporary failure of the water supply, the cylinder head in these engines contains a fusible plug, which will melt out in case of such failure and give warning by the noise of escaping gases. It is said, however, that the engine will run in this event for at least 10 min. without the water.

This method of cooling is certainly one that makes decidedly for reduced cost and ease of manufacture, and the result of further experience in its use is looked for with much interest. The principle will no doubt be taken up by manufacturers, and we may expect to see engines of this kind upon the market in the near future.

The Meriam Steam Process

This is a method by which the heat ordinarily lost in the water jacket of an internal combustion engine, and also the greater part of that carried off in the exhaust, may be recovered and turned to useful account. That the loss from the jacket alone usually amounts to about ⅓ of the total heat value of the fuel has long been a regretted fact, and it is well known, too, that the cylinder of a large engine operating under the ordinary conditions cannot be effectually cooled by water which is much hotter than 170 deg., and by reason of this relatively low temperature at which the water must be discharged it has heretofore been impractical to make use of this waste heat to any appreciable extent. Why a gas engine cylinder is not sufficiently cooled by water in which the temperature is no higher than that of an ordinary steam engine has always been a mystery, but the reason of this has lately been discovered by J. B. Meriam, of the Bruce-Macbeth Engine Co., and is as follows:

When the water approaches the boiling temperature, the bubbles which are formed adhere to the metal surfaces and to a certain extent keep the water out of contact with the combustion chamber walls. These bubbles increasing in size and number as the boiling becomes more rapid, act as an insulation between the water and the iron; but the inventor has further discovered that this action may be entirely obviated by forcing the water to circulate at a rapid rate through the jacket, by means of a pump of any suitable form.

In this way, the jacket may, in connection with a suitable receiver, be utilized as a steam generator, and the steam thus formed and held under pressure contains all the heat absorbed by the water. This, in conjunction with an auxiliary device by which the greater part of the heat of the exhaust is also employed for the production of steam, forms the arrangement which represents the Meriam Steam Process; and when we consider that in common practice the combined losses of the jacket and the exhaust in a gas engine amount to ⅔ of the total heat developed by combustion, and that by this process something like 75 per cent of this loss may be recovered, its value becomes apparent.

The invention is termed a process for the reason that it does not necessarily involve a specific structure, or a definite mechanical arrangement, but is essentially a system. This system is based, however, upon an original discovery, made by the inventor as above noted, and has been allowed a strong patent.

It is probable that this process applied in combination with a first class oil fuel engine would afford the highest degree of economy ever attained in any form of the heat motor.

General Remarks

In engines of the high-pressure Diesel class in which the governing is effected entirely by means of fuel control, the compression of the air requires a fixed amount of power, regardless of that developed by the engine. When running under full load this is about 12½ per cent of the total output, but this figure goes up in direct proportion as the load falls off; so that at half load it would be 25 per cent, or 50 per cent at ¼ load; and such an engine running without load would develop somewhat more than ⅛ of its maximum power. A part of this would be absorbed in overcoming the friction of the moving parts, and the remainder would all be consumed in compressing the air. This is true, too, but to a much less degree with other engines, and to avoid this disadvantage in a power installation it is necessary to see that the capacity of the engine is not too greatly in excess of the actual requirements.

In the matter of further development in gas engine construction, the trend is strongly in the direction of the Diesel system or its modifications, and this is no doubt for the very obvious reason that this principle is the one best suited to the use of low priced oil fuels. These engines should, under favorable conditions, develop an average output of 1 hp. per hr. on 0.6 lb. of fuel, and this fact, with the abundant and ever increasing supply of low grade asphaltum oils now available, is certain within the next few years to place this means of power production in advance of all others.

As to the comparative advantages of the high and the medium compression systems in engines of this kind,

there is apparently a division of opinion, and no doubt each method has certain merits of its own not possessed by the other. In the semi-Diesel or hot bulb engines, the injection of water is often used to assist the combustion of the oil; but its employment for this purpose is not so urgently demanded as in engines of the mixed compression class; and in those of the full Diesel type employing a compression of 500 lb. per sq. in., the water is not needed at all, the fuel being promptly ignited and fully consumed in the air of the charge. The conditions must be such, however, that the full degree of compression is invariably reached, or this desirable result will not be secured.

Convertible Combustion Engines*

By A. E. L. Chorlton

GROUP 3 embodies engines with a moderate compression suitable for developing higher powers. The range of the compression of these engines lies in between that of Groups 1 and 2, and usually is from 150 to 300 lb. The compression of 150 lb. is suitable for most forms of producer gas; but it is not usually exceeded, for the reason that pre-ignition of the compressed charge is more prevalent in very high compression gas engines. On the other hand, it is necessary for all compressions below self-ignition compression, as is the Diesel, to employ some auxiliary means to obtain the necessary height of temperature for the proper combustion of the residue oil. Normally, as in the second engine, Fig. 2, the additional heat is obtained by an unjacketed surface or combustion bulb, at the cylinder end. This temperature-raising device is employed, with other agents, to give

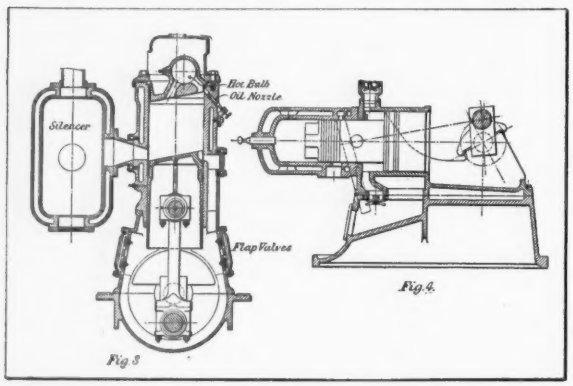


FIG. 3. VERTICAL TYPE ARRANGED FOR OIL
FIG. 4. HORIZONTAL TYPE ARRANGED FOR GAS; STEPPED PISTON AND WATER COOLED CYLINDER HEAD

the best effects, on the score of economy; for the lower compression, such as 150 lb., a satisfactorily running oil engine is obtained; the economy, however, is not quite so high, and the range of fuel not so fully extended.

The various devices employed in and around the question of temperature, compression, and convertibility of this group of engines may be considered by subdividing it under the following heads:

(a) Engines working with a compression not exceeding 150 lb., both for oil and gas; these may employ pocket-firing, with or without air-injection, for one, and electrical ignition for the other, or some combination, the smaller compression not involving material mechanical change of the parts.

(b) Engines working with a higher compression for oil than gas, involving some modification of the combustion chamber by substitution of a part for oil as against a part for gas; otherwise maintaining the simplicity of both types.

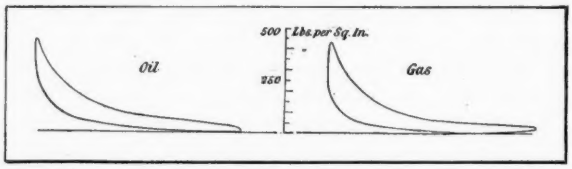


FIG. 5. ENGINE INDICATOR DIAGRAMS OF OIL AND GAS OPERATION

(c) Engines obtaining the necessary change from gas to oil by temperature control of the air charge, together with alternation of the valve settings.

(d) Engines employing the super-compression of Dr. Dugald Clerk, to control effectively thereby the compression required for either fuel. (Final ignition temperature by other means.)

Under subdivision (a) there is a large number of engines which are used only for oil, but which might, without material alteration, become effective in the use of gas, although the whole combination is not as efficient as the highest individual member. As an instance of this division, there is the 2-cycle Bolinder engine, at present only used for oil, although originally used by Day for

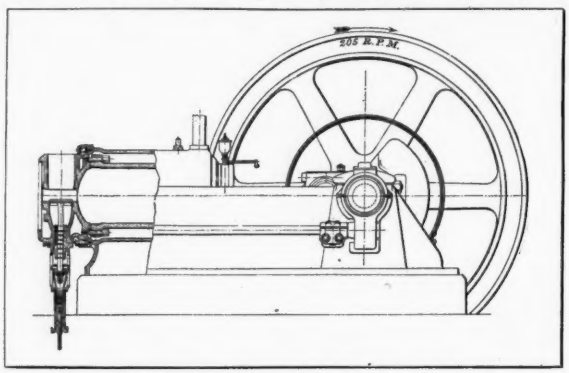


FIG. 6. DIAGRAM OF CONVERTIBLE ENGINE

gas, Fig. 3. When made with a stepped piston, as in Fig. 4, with uncooled cylinder head substituted by a water cooled one, a gas engine for small powers is more or less effectively obtained.

For large powers it is usual to separate the air and gas in the pump, and the engine becomes, therefore, not quite so simple a proposition to change over from the use of oil to the use of gas. In the 4-cycle engine the change from oil to gas involves a removal of the unjacketed part of the combustion head for that of a gas type, with electrical ignition. A variation of this type, employing air injection for the fuel, combined with pocket-firing for the ignition of the charge, secures considerable economy when used with oil. The advantage, however, in using more or less the same compression for both oil and gas is lost through the need of a high-pressure air

*Continued from page 1053, Nov. 15 issue.

compressor (as with the Diesel) and the employment of double-injection needles. For higher powers and the best economies, it is necessary to go considerably further, for, unless the economy upon oil is approximate to that of the Diesel engine, the convertible type will not become of any real lasting value.

In considering the next division—namely, (b)—a useful comparison of its possibilities is given in tabular form, for engines of the same cylinder dimensions:

	Compression lb.	Abnormal Maximum Pressure lb.	M.e.p. lb.	B.t.u. per B.hp.-Hr.
Oil engine...	250-280	600	80	8100
Gas engine...	150	600	80	8500

It will be seen from this that the outputs and general figures relative to the engine bear a great similarity. Further, as in Fig. 5, the diagrams actually taken when running on oil and gas are also shown to be

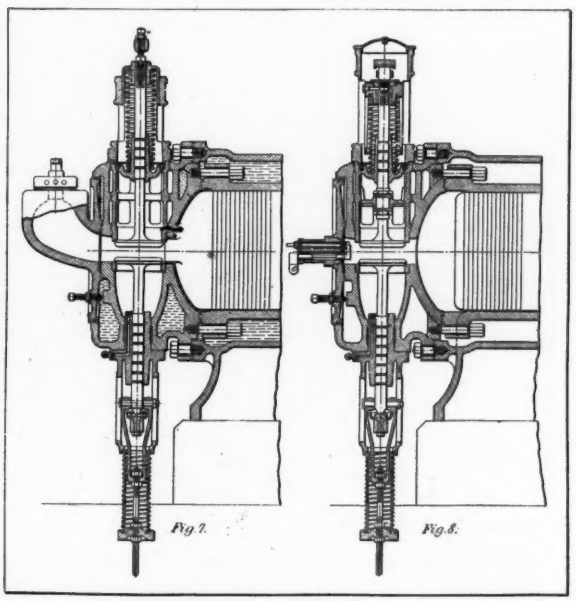


FIG. 7. ARRANGEMENT OF CONVERTIBLE ENGINE FOR OPERATION ON OIL

FIG. 8. ARRANGEMENT OF CONVERTIBLE ENGINE FOR OPERATION ON GAS

of similar nature. The possibilities, therefore, of this type of convertible engine appear, from these indications, to be very great; and an engine which has at present been made in considerable numbers to fulfill these conditions is shown in Figs. 6 to 8. These show clearly that in both cases the engine presents the ordinary features of the 4-cycle engine, and the only change involved in converting from oil to gas lies around the combustion bulb of the oil engine, in which the fuel oil is injected, and in the change from an oil type to a gas type piston.

Figure 7 indicates the arrangement of parts when running on oil and Fig. 8 when running on gas. As the essential feature of the convertible engine is that it must maintain the economy when on either fuel, the curve is given in Fig. 9, showing the consumption of this type engine when running on Russian crude oil. On gas, where it is seen that the engine resembles the well-known 4-cycle type, the consumption figures are in parallel with those which have been taken on various occasions by different experimenters.

In group (c), the use of the arrangements may be said to be one of mechanical and constructional convenience, for they can hardly be defended on the score of efficiency. In one method the jacket of the cylinder

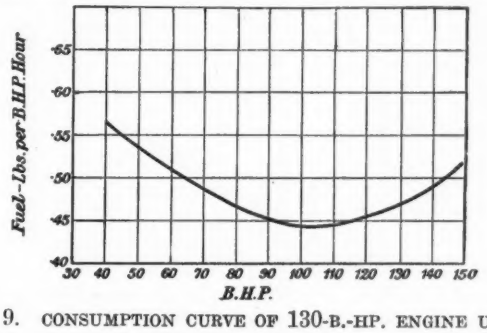


FIG. 9. CONSUMPTION CURVE OF 130-B.-HP. ENGINE USING RUSSIAN CRUDE OIL

cover or breach end is formed to withstand a pressure, and is worked in the manner of a boiler. The increased heat is impressed in the charge of air during the compression stroke to raise the temperature sufficiently to afford ignition. This arrangement thus replaces the hot-bulb or unjacketed end of the cylinder. It has some advantages in that it is perhaps more controllable, and the steam generated may be used for some useful purpose, perhaps in conjunction with an exhaust-heated boiler for an auxiliary steam-cylinder on the main engine. The water-injection of some hot-bulb engines is

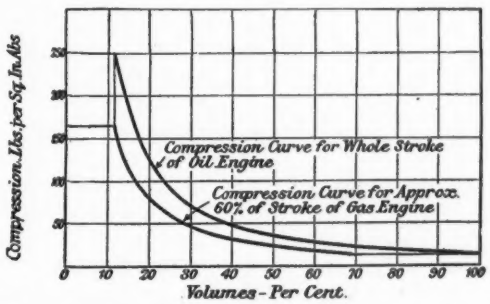

Compression. Lbs. per Sq. In. Abs
Compression Curve for Whole Stroke of Oil Engine
Compression Curve for Approx. 60% of Stroke of Gas Engine
0 10 20 30 40 50 60 70 80 90 100
Volumes - Per Cent.

FIG. 10. VALVE SETTING, COMPRESSION CURVES FOR OIL AND GAS

also done away with. This type of engine is unusual in practice. When in use as a gas engine, such a convertible engine would have to dispense with the pressure-jacket temperature when using the lower compression and temperature needed for such an engine. Actual heating of the inlet air may be a practical convenience for dealing with a particularly refractory oil, not amenable to the available compression of the engine. The valve-setting of an engine may be modified, as in Fig. 10, to give suitable compressions for oil and gas; this can be worked in conjunction with the temperature arrangement just described. The gas engine suffers in loss of output, as is shown in the diagram.

The Clerk super-compression engine, of Group D, is a much more suitable and promising type for dealing with the variable compression problem of the convertible engine. In this engine, the principle of which is prob-

ably well known, an actual engine built some years ago being shown in Fig. 11, an extra charge of air or inert gas is added to the working mixture at the end of the suction stroke. By this means, owing to the, so to speak, "watering" of the charge, much lower maximum flame temperatures are obtained, and a higher mean cylinder pressure rendered possible. For the purpose of the convertible engine, it is mainly suitable, as by varying this amount of added air the compression can be adjusted

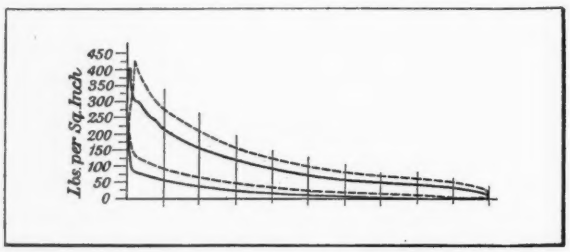


FIG. 12. INDICATOR DIAGRAM OF CLERK ENGINE

between wide limits, the final temperature being controlled by any of the previously indicated means. For instance, with a compression of 300 lb., maximum, the full displacement of the air-pump may be used; for the lower compression of the gas engine, one can, by any suitable valvular means, as an ordinary bypass, reduce the amount of discharge as required.

The commercial value of this type has hardly been determined in practice; but it would almost appear that its possible usefulness will only come in for large engines, for, after all, it is an addition, if not a complication, to the ordinary engine of everyday use. The diagram of such an engine, from one of Dr. Clerk's papers, is given in Fig. 12. The engine really uses a 2-stage compression, but not expansion.

The conclusion the author arrives at is that, for powers up to, say, 1000 b.hp., the type of engine represented by the "Ruston," class B, is the most suitable as a convertible engine, while for still larger powers, when tandem engines and size and weight of removable parts become a problem, the Clerk super-compression type offers interesting and hopeful possibilities.

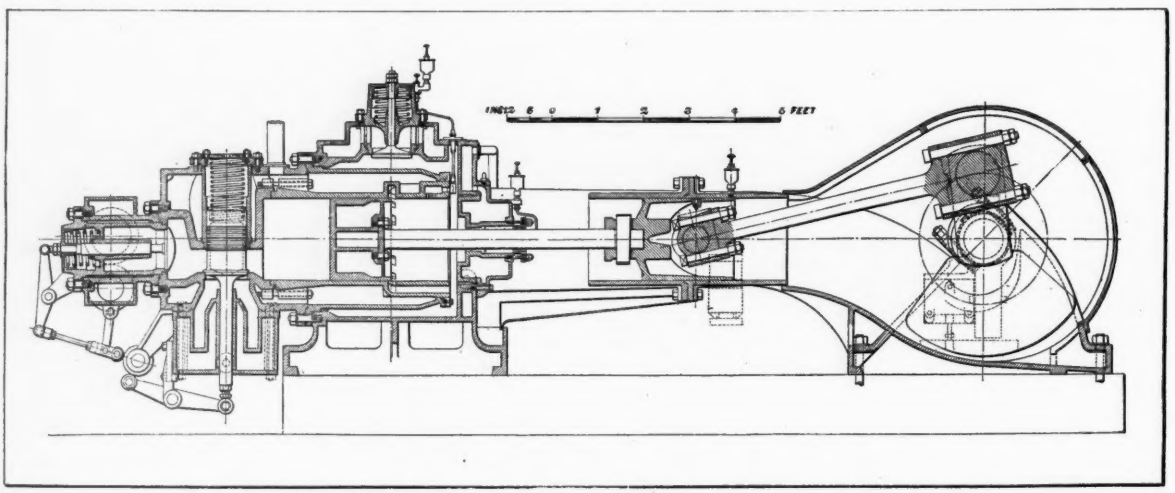


FIG. 11. CLERK SUPERIMPOSED COMPRESSION ENGINE

Conflicting Boiler Laws

IN the discussion on the conflict of state and national laws, C. B. Auel in American Industries calls attention to the fact that a steam boiler built in Detroit, and which will work perfectly in that vicinity, would not operate at all in Philadelphia, according to the present laws, and would surely blow up in Boston. This is, of course, absurd, and as any city can change its laws yearly, it is a difficult, if not impossible matter for manufacturers to keep abreast of the changes, and to manufacture to meet all standards.

It is for this reason that the Association for the Promotion of Uniform Boiler Laws has been formed, and the effort is being made to secure the adoption by all states of uniform laws, based practically on the American Boiler Code as issued by the A. S. M. E. The code is the result of careful study by a committee of men eminently fitted for the work, and embodies the best thought and knowledge of boiler manufacturers and users as to the proper construction for safety and durability.

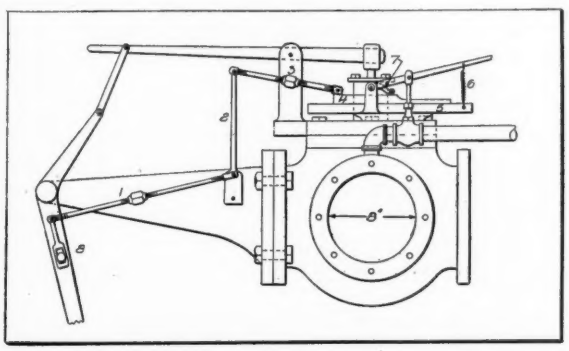
FOR THOSE INTERESTED in export business, especially to Latin-American countries, the publication of a guide book, "Consular Regulations of Foreign Countries," by the Department of Commerce of the United States will be of interest. This is No. 24 of the tariff series issued by the Bureau of Foreign and Domestic Commerce of the Department of Commerce, contains 66 pages, and is sent direct from the Superintendent of Documents, Government Printing Office, Washington, D. C., for 10 cents a copy. It contains complete description of the shipping documents required in all Latin-American countries and Canada, giving facsimiles of consular invoices used, and pointing out features which might be overlooked by an exporter. The chapter for each country has been revised by the consular representative of that country in the United States, and American banking institutions and commission houses have also been consulted. The use of this book, and the preparation of shipping documents in correct form, will save exporters and their customers in Latin-America from fines and delays in delivery of shipment.

LETTERS DIRECT FROM THE PLANT

Cash Paid For Ideas Accepted. Sketches Desirable.
We Make The Drawings

Method of Releasing Back Pressure

IN TRAVELING from one engine house to another, you will often notice many peculiar mechanical appliances that are made by the engineers in charge of the plant. The sketch shows one which I have known to be in operation for over 10 yr. and giving perfect satisfaction on hoisting engines. Engineers know what it is to release back pressure with a chain attached to the back pressure valve in such a way that it will hang down along the throttle handle so that you can reach it and pull it with your thumb. Others have the throttle valve with a push lever operated by the foot. Both of these methods are tiresome, so I will sketch in detail the parts of the above-mentioned apparatus that other engineers may try this method of back pressure release.



METHOD OF RELEASING BACK PRESSURE ON HOISTING ENGINE

After the throttle is shut, you still have further swing of throttle arm in order that you can lock your throttle. This movement is used to operate the back pressure valve. You notice that when the throttle is shut, the back pressure valve is also shut. But any movement toward the locking of the throttle will open the back pressure valve. When the throttle is locked, the back pressure valve is wide open. This method you can see is a handy way to release the back pressure. By following the instructions here given, any engineer can make this apparatus in a short time.

The reach rod, part No. 1, can be made from 1-in. round iron. Ends can be tapped and screwed on and turnbuckle placed in center so that you can adjust the movements to suit. The holes in part No. 2, the rocker arm, should be made so that the bolts will turn easily. Another reach rod, part No. 3, is the same as part No. 1, but shorter. Don't neglect to use the turnbuckles, so you can adjust properly. The slide or crosshead, part No. 4, is made of 2 pieces of iron bolted together, giving a T-shaped cross section. One piece is drilled and tapped, the other is counter sunk so that both sliding surfaces will be even and clear. This part must slide back and forth, smoothly, in part No. 5, the guide, which is made of 6 pieces of iron to fit the slide; 5 of these go to make up the guide and a ¼-in. iron on the bottom makes the base by which it is bolted on the throttle between the nuts and the top of the throttle. This ¼-in. iron base should be drilled to slip over 3 of the stud bolts in top of throttle and in this way it is held steady and square with throttle.

The lifter for the valve, part No. 7, engages slide No. 4, which raises roller on part No. 7, giving lever an upward movement to open the valve. The pedestal supports the lever and is bolted on the base. Part No. 8 is slotted out as shown to allow for adjustment and is bolted on the throttle arm. AN OBSERVER.

Cost of Poor Packing

HOW MUCH does a poor kind of packing cost?

Let me answer this question from the friction standpoint alone: I know that a packing may be poor in more ways than one, but the poorest kind is the kind that absorbs too much power. Packing should consume as little power as possible, for the same reason that bearings should consume as little power as possible.

The best way I know of, to test the friction qualities of packing, is to take the time required for the engine to come to rest after the steam is shut off, both before the new packing is applied and after. If the engine runs for a longer time with the new packing in place, and if the new packing performs its function properly, the new packing is better than the old. If the engine runs for a shorter time with the new packing in place, the old packing was best if it still performed its function properly.

To compute the friction cost of a poor packing above that of good packing, then, in actual dollars and cents, I have evolved this formula:

$$\left.\begin{array}{l}\text{Cost of excessive packing}\\ \text{friction per year.}\end{array}\right\} = \frac{C\,H\,D\,W\,V^2}{550}\left(\frac{T_1 - T_2}{T_1\ T_2}\right)$$

where

C = cost in dollars of the power in your plant per horsepower-hour;

H = number of working hours a day;

D = number of working days a year;

W = weight of flywheel rim in pounds. (This is easily computed. One cubic inch of cast iron weighs 0.26 lb.);

V = peripheral velocity of the flywheel in ft. per second;

T_1 = time in seconds required for the engine to come to a stop with the good packing in place;

T_2 = time in seconds required for the engine to come to a stop with the poor packing in place.

For example, if your power costs \$0.01 per hp.-hr.; if you work 10 hr. a day and 300 days a year; if the weight of the flywheel is 2000 lb.; peripheral velocity a mile a minute is 88 ft. per sec.; time with good packing is 65 sec., and with poor packing 60 sec., I compute the excessive cost of packing friction per year to be almost \$34. With figures substituted in the formula, I get:

$$\frac{\$0.01 \times 10 \times 300 \times 2000 \times 88 \times 88}{550 \times 32}\left(\frac{65-60}{65 \times 60}\right) = \$34,$$

approximately.

N. G. NEAR.

Carbon Brush Specifications

RECENTLY our company was in the market for a supply of carbon brushes for our motor equipment. Following are the specifications submitted by one of the bidders for the contract. As may be noted, there is considerable difference in the composition of the brush recommended for nonslotted and slotted commutators, and also for interpole machines with nonslotted commutators. While these specifications may not conform exactly to the views expressed by the writers of some of the many articles written on this subject, a discussion of some of the items may be of interest.

(A) Stock carbon for nonslotted commutators, except on interpole machines:

1. Hardness by scleroscope shall be approximately 35.

2. Shall be of uniform texture throughout and commercially free from mechanical flaws and any mineral matter above ½ of one per cent except mica.

3. Shall contain a sufficient quantity of abrasive material to preserve a medium brown color on the commutator without blackening or cutting of the commutator.

4. Specific resistance shall be approximately 0.0012 ohms per inch cube.

5. Current-carrying capacity shall be at least 60 amp. per square inch on noninterpole motors at 70 deg. F.

6. Shall be capable of operating without injurious sparking or heating when the commutator speed is 3500 ft. per min.

7. The breaking strain of stock 1 in. square shall not be less than 2750 lb., the piece being held by dull knife edges 2 in. apart and the strain applied by one dull knife edge between and 1 in. from the opposing 2.

8. Self-lubricating quality shall be constant for any temperature up to 300 deg. F.

(B)—Stock carbon for slotted commutators and for nonslotted commutators and interpole machines:

1. Hardness by scleroscope shall be approximately 60.

2. Shall be of uniform texture throughout and commercially free from mechanical flaws and any material other than carbon.

3. Shall contain no abrasive material.

4. Specific resistance shall be approximately 0.0014 ohms per inch cube.

5. Carrying capacity shall be at least 90 amp. per sq. in. at 70 deg. F.

6. Shall be capable of operating under normal conditions without injurious effects, sparking or heating when the commutator speed is 5500 ft. per min.

7. The breaking strength of stock 1 in. square shall not be less than 4500 lb., the piece being held by dull knife edges 2 in. apart and the strain applied by one dull knife edge between and 1 in. from the opposing 2.

8. Self-lubricating qualities shall be constant at any temperature of operation.

9. To assist commutator the combined contact drop of the positive and negative brushes shall not be less than 2 v. nor more than 2.5 v.

(C)—Pigtails:

1. Unless otherwise ordered, shall be of single, flexible, round copper cable of an electrical carrying capacity higher than that of the brush to which it is attached.

2. Unless otherwise ordered, the cable shall be attached to the brush by copper graphite cement of a composition unaffected by a temperature of 500 deg. F. and so anchored that there is no appreciable drop in voltage between the cable and carbon, and of such durability that the resistance of the connection will not increase materially during the life of the brush.

From the foregoing, it is evident that the brushes recommended for class B slotted commutator and interpole machines are much harder than required for class A; class B brush shall be free from abrasive material while class A shall contain sufficient abrasive material to give the commutator a brown polish without blackening the commutator; class B brush shall be capable of operating at a much higher speed without sparking; the current carrying capacity shall be 30 amp. higher per square inch than is required for class A; the breaking strain is considerably higher in class B and more exacting self-lubricating properties are required, all of which shows that the brush is designed for considerably harder service, heavier overloads and longer life than those of class A.

The characteristics of the interpole motor are such that it can be operated under heavy overload without excessive sparking, and is well adapted to a line of work that cannot be as well done by any other type of machine. This severe service makes it essential that the commutator and brushes in which most motor troubles lie shall be especially adapted for the work and capable of carrying a greater amount of current without showing signs of distress than required in other types of motors.

J. C. HAWKINS.

Hunting for Trouble

TO LOCATE knocks in Corliss engines, or engines having means of working the valves by hand, put the crank on dead center and have a helper work the valves, letting steam into each end of the cylinder in rapid alternation.

While this is occurring, inspect all points of motion, such as crankshaft, crankpin and wristpin. Also see that the pillow block is not moving on the girder and that the girder is secure to the cylinder, and whether or not crankpin has worked loose. Next, get the crank at half stroke and work the valves again, looking for loose crosshead shoes and a loosely connected piston rod end.

If there is no means of working the valves by hand, the engine will be small enough for one or more helpers to turn the flywheel by hand. Block the crosshead at about the center of stroke with some lengths of scantling wedged up tightly, so it cannot move in either direction. Then have the helpers move the flywheel as far as possible either way, and hunt for lost motion as before.

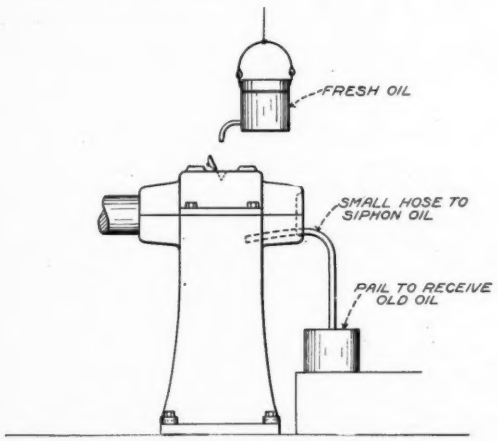
This method will show everything except piston trouble. The process of hunting for knocks is always done by Sherlock Holmes' method; that is, find out first where there are no knocks. More can be discovered about an engine in 5 min. by going over it as indicated, than can otherwise be found in a week.

H. K. SCHOLEFELD.

No Oil Grooves Results in Hot Bearings

A SHORT time ago, I was asked to look at a bearing on a large generator that was running hot; it had been necessary to keep an attendant putting in new oil and drawing off the old.

First, I rigged up the scheme shown in diagram, the siphon having the same flow as the fresh supply. Then, as soon as possible, the generator was stopped. On making a few inquiries, I found the bearing had been in



TEMPORARY CONTINUOUS OILING SYSTEM

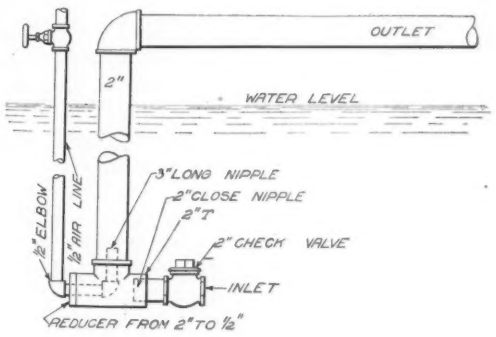
only since the last summer, having been rebabbited on the job. I had them remove the housing and found there were no oil grooves cut in the bearing; no wonder it ran hot, and more's the wonder it ran a week. I have known of quite a number of cases where a bearing has been put back without cutting oil grooves.

G. MACLEAN.

Pump Made of Pipes and Fittings

IN A Western mine where I was employed, a shaft long abandoned and full of water had to be emptied. Nothing else was at hand in the line of pumps but a common well pump, and a very small one at that, which did not appeal to me. There was a gas engine and air compressor at the mine and I made my own pump and had it running in less than 3 hr.

I took a 20-ft. length of 2-in. pipe, a 2-in. tee that I screwed on the end of the pipe; on one side of the tee a 2-in. close nipple and 2-in. check valve; on the other side of the tee a reducer 2 to ½ in. Then I made a nozzle as follows: A piece of ½-in. pipe 3 in. long, with thread 1½ in. on one end so as to extend far enough to have a ½-in. elbow in the inside; on one side of the elbow, pointing up in the center of the 2-in. pipe, a nipple 3 in. long; on the end of the nipple, bushing side, an elbow and a ½-in. pipe and valve connected to the air line.



HOMEMADE AIR LIFT PUMP

The construction is simple. Enough air is admitted so as to lift the water up, the whole is submerged, and as the air and water are going up the pipe water enters continually by the check valve. For the first 20 ft., with a pressure of 60 lb. at the receiver, the water was raised at the rate of 900 gal. per hr. As the water lowered, I added another length of 2-in. pipe for the water and a ½-in. for the air.

CHAS. LABBE.

Variable Speed Compensating

IN A shop in which I was recently employed, it was required that a certain line shaft be so arranged as to get greater and lesser speeds from it at various intervals of the day; there are sometimes as many as 8 or 10 changes in one day.

This could have been taken care of by means of a counter-shaft and cone-pulleys, but this would have meant a shifting of the belt, which is always more or

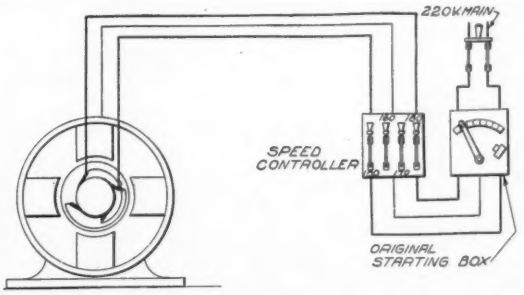


DIAGRAM OF APPARATUS FOR CHANGING SPEED OF D.C. MOTOR

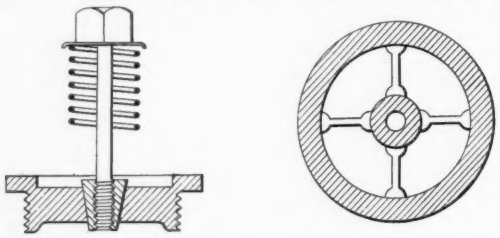
less trouble. The cost of erecting as well as the cost of material for a counter-shaft would have been greater than that of the plan which was adopted, as shown in the accompanying diagram. This plan has proved to be a successful solution to the problem, and is very easily operated, the change of speed being made by opening and closing knife switches on speed controller which is located near the starting-box.

The scheme consists in compensating IR drop in armature windings by introducing a shunt coil differentially connected between field and armature circuits. The device can be installed and tested without shutting down motor, if necessary. At slight extra cost, switches may be provided for any intermediate speeds without changing the wiring. F. I. H.

Pump Valve Trouble

We had a 6 by 4 by 6-in. outside end packed plunger pot valve type boiler feed pump which gave us a great deal of trouble by the water valve stem lifting up and sticking in the water valve seat. We would have to stop the pump, start the other pump and take off water valve cap to get it loosened up.

We had an idea that the water valve stem lifted too high, so we drilled a hole in the center under side of water valve cap, tapped it out for ½-in. rod about ¾ in.



VALVE SEAT WHICH PROVED SUCCESSFUL

long and threaded this. But this did not remedy the trouble; the same water valve stem continued to stick. So we thought of reconstructing the valves. We then made a pattern for the deck valve type and had them cast of brass at the cost of 20 cents a lb. Having our own lathe, we soon had them shaped up, put in the pump ready for business and our troubles were over.

A. U. Wolfe.

Preventing Stoppage of Brine Tank Drain Pipe

The iron tank shown in Fig. 1 is located in an ammonia compression refrigerating plant to contain the chloride of calcium brine by which a certain part of the system is defrosted at regular intervals.

When making this brine, a centrifugal pump is used to circulate it until the required density is reached. Granulated calcium is used, which is shoveled into the tank while the brine is in circulation. After several defrostings this brine becomes too weak and some of it has to be run to the sewer in order to strengthen that remaining. Quite frequently the 1½-in. service elbow became stopped. Some of the calcium collected at this point, forming a hard mass in these connections up to the 1½-in. valve. Whenever this would occur, these fittings had to be removed and immersed in warm water, when the calcium would drop out and the fittings could be replaced.

In order to overcome this inconvenience, the engineer devised the arrangement of parts shown in Fig. 2. A 1¼-in. coupling with a thread cut on the outside is used as a bushing, which is screwed into the hole in the bottom of the tank.

The connections from this to the 1½-in. cast-iron tee, which is bushed, have been changed to 1¼ in. The idea of using the 1¼-in. coupling as a bushing, is to provide threads into which the piece of 1¼-in. pipe is screwed, extending above the top of the tank about 6 in. The cap on the end, I presume, is placed there for appearance's sake. Whenever the drain is not in use, this piece of pipe is left in the position shown, and it is obvious that with this arrangement, these connections

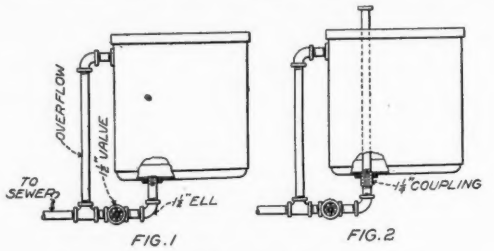


FIG. 1. ORIGINAL BRINE TANK PIPING
FIG. 2. PIPING ARRANGED TO PREVENT STOPPAGE OF ELBOW WITH CALCIUM

cannot become stopped with calcium. When the drain is to be used this pipe, which is never screwed in more than hand tight, is unscrewed and placed to one side. After a part or the whole of the brine has been run into the sewer, this piece of pipe is replaced, by simply screwing it into the coupling. Karl Hoffman.

Changes in Feed Water Piping

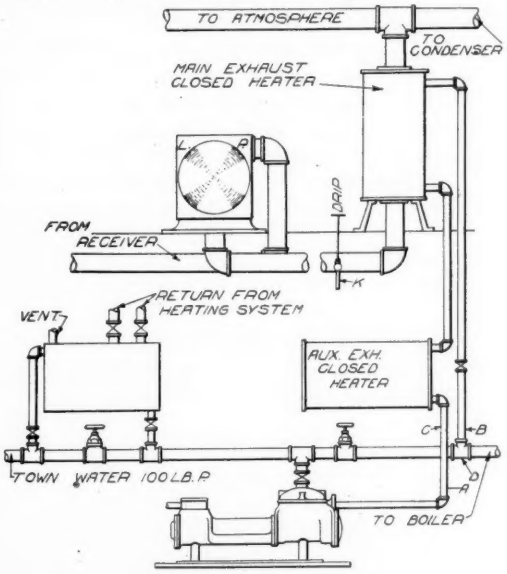
Here is a rough sketch of the feed water system of a plant a friend of mine gave me. He took charge of the plant, although it was a very poor paying position, because the superintendent promised that half of everything he saved would be given to him, and as he looked over the place he thought he could save considerable. After he tackled the job, the first change he made was in the heating system of the boiler feed. The temperature of the feed water was 140 deg. He changed pipe A to pipe B and put pipe C into pipe D, which changed the direction of the flow of water, and this changed the temperature of the feed from 140 to 204 deg. He pointed out to the manager that by raising the temperature of the feed water 10 deg. with heat that would otherwise go to waste, he saved 1 per cent on the coal bill and as he had increased the temperature 64 deg., he was entitled to half of the saving in the coal bill which he claimed was about 6 per cent.

This must have amounted to a good sum, for after the superintendent figured for awhile on my friend's figures, my friend was told that the superintendent would increase his pay $5 a week, but could not give him half of what he claimed to have saved.

My friend did not like it, as he thought he ought to have what was promised, but when he noticed that instead of 26 in. of vacuum he now had only 23 in. after the change, he thought it the best policy to keep quiet.

The master mechanic of the place thought the poor vacuum was caused by air leaks, and tinkered with the atmospheric valve and vacuum pump but failed to find the trouble, and the question arose at that time whether the cause of the poorer vacuum was caused by the change made if there were any economy in putting a heater between the low-pressure cylinder and the condenser.

Things ran along like this till spring, when the water being high and the engine carrying a light load, they thought it would be a good time to clean and inspect a couple of the boilers. After the inspection, the fireman was told to fill them and get them back on the line again so that they could clean the other 2 boilers. So the fireman shut the feed valves on the 2 steaming boilers and speeded up the pump, sending the comparatively cold water into the boilers.

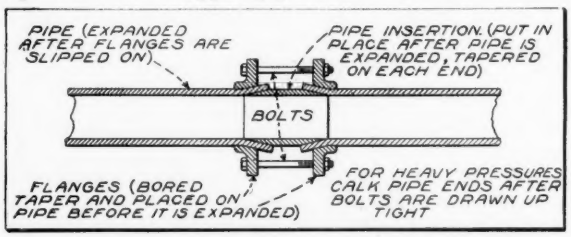


FEED WATER PIPING

My friend happened to be standing close to the low-pressure cylinder at that time, and that began to slam. He hardly knew what to do, but grabbed the valve marked "drip" on the sketch, and opened it up as quickly as possible, then ran to the boiler room and stopped the pump. Now when they are filling a boiler they send it through the pipe directly without using the pump or heaters and they are also having a vacuum trap installed at K. J. E. K.

A Pipe Joint

THE SKETCH shows a pipe joint, handy in repairing a break in a lead or copper pipe which is too thin or too large to repair in the ordinary manner, or where facilities are lacking to make ordinary repairs. I have repaired a 4-in. copper pipe with only a file to make

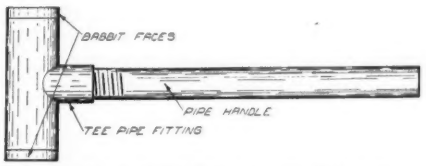

PIPE (EXPANDED AFTER FLANGES ARE SLIPPED ON)
PIPE INSERTION (PUT IN PLACE AFTER PIPE IS EXPANDED, TAPERED ON EACH END)
BOLTS
FLANGES (BORED TAPER AND PLACED ON PIPE BEFORE IT IS EXPANDED)
FOR HEAVY PRESSURES CALK PIPE ENDS AFTER BOLTS ARE DRAWN UP TIGHT

AN EASILY CONSTRUCTED AND RELIABLE PIPE JOINT

the fits. After the repair this pipe stood a pressure of 60 lb. per in. A piece of 4-in. extra heavy pipe was used for the insertion, and a couple of 4-in. pipe flanges were filed out for clamps. Four ½-in. bolts completed the job. AN OLD SUPERINTENDENT.

Babbit Hammers

REFERRING TO "Fishday's" babbit hammer, I send herewith a drawing showing how I make them out of ordinary gas pipe and pipe fittings with babbit used for a "filler."

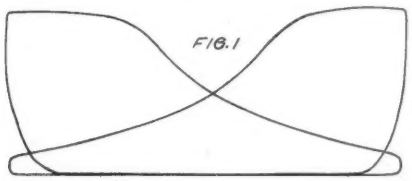


AN EASILY CONSTRUCTED BABBIT HAMMER

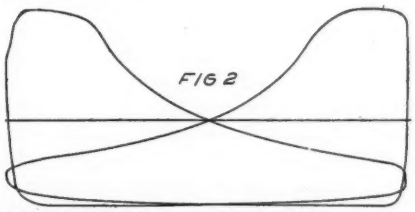
Any weight hammer can be made by simply using different sized fittings. N. G. NEAR.

Indicator Cards from Large Corliss Engine

SHOWN HEREWITH are 2 indicator cards taken from the high and low pressure cylinders, respectively, of the Fulton Corliss engine described on page 201 of the Feb. 15, 1915, issue of this paper.



WHICH ENGINE.... 5 R. P. M....90
WHICH CYLINDER.. H.P SCALE...80
BOILER PRES. 150 LB. PISTON DIAMETER 36"
PRES. IN RECEIVER. 15 LB. PISTON STROKE..54"
VAC. PER GAGE...25.4 IN



WHICH ENGINE...5 R. P. M.....90
WHICH CYLINDER..L. P SCALE.....16
BOILER PRES..150 LB. PISTON DIAMETER 76"
PRES. IN RECEIVER 15 LB. PISTON STROKE...54"
VAC. PER GAGE. 25.4 IN.

FIG. 1. CARD FROM HIGH-PRESSURE SIDE
FIG. 2. CARD FROM LOW-PRESSURE SIDE

That shown in Fig. 1 was taken on the high-pressure side with a boiler pressure of 150 lb. gage, a receiver pressure of 15 lb. gage and a vacuum of 25.4 in. The scale of indicator spring used was 80.

Figure 2 illustrates that card taken on the low-pressure side under like conditions. In this case, however, the scale of spring used was 16. F. B.

IT TAKES a strong man to be highly efficient. He must abandon prejudices in mind and habits in action; must throw away unbeliefs; learn to think that little which once seemed large, and that vital which was deemed unimportant. Improving a method, getting a machine, hiring an abler man may be done without grasping the first principles of efficiency.

Questions Answered and For Answer

Expert Help When In Trouble. If You Want Quick Answer Enclose a Stamp

Stay Bolt Calculations

How would you figure the safe allowable working pressure for hollow stay bolts?

2. How would you calculate the required size of a hollow stay bolt?

3. Why is the cross-sectional area of a Manning boiler increased at the bottom?

4. What is meant by the crushing strength when we say 95,000? H. S.

ANSWERS

The allowable stress on stays and stay bolts is given in the Massachusetts Rules as follows:

Very mild steel or wrought iron stay bolts, in sizes up to and including 1¼ in. diameter or equivalent area, 6500 lb. per sq. in.; sizes over 1¼ in. diameter or equivalent area, 7000 lb. per sq. in. The area of the stay bolt is figured as the smallest area at any point.

In the case of a hollow stay bolt, which is not turned down at the center but is made of a straight piece of steel, threaded on the ends and drilled through the center, the smallest section will be between the bottom of the thread at the end and the hole in the center.

Find the area of a circle whose diameter is that at the bottom of the thread. From this subtract the area of a circle whose diameter is that of the hole drilled out. This gives the net area of the bolt, and this multiplied by the allowable stress per square inch will give the allowable load on the bolt.

In the case of a turned-down stay bolt, it is quite likely that the diameter of the bolt between threads may be less than the diameter at the bottom of the thread. In this case, subtract from the area of the outside cross-section, at the smallest point, the area of the hole, to give the net area. Stay bolts are ordinarily threaded 12 threads to the inch, and the outside diameter of the thread minus 0.1443 will give the diameter at the bottom of the thread.

2. This process would be the reverse of the one preceding. Divide the total stress to be carried by the stay bolt, by the allowable stress per square inch. This gives the net area. Then determine the size hole to be bored, find the cross-sectional area of this hole, and add it to the net area. This gives the gross area for the outside diameter at the smallest point. From this find the outside diameter permissible, and if it is to be a straight bolt, add to this diameter, which will be that at the bottom of the thread, 0.1443 in. to get the outside diameter.

3. The idea of enlarging the Manning boiler at the bottom is to get a larger grate area. In a straight-sided vertical boiler, the furnace is constricted because of the necessity of the water leg around the furnace, which reduces the number of flues which can be put into a given shell, and also reduces the grate area.

In the Manning boiler, by enlarging the lower part below the lower tube sheet, a larger grate area is provided, thus increasing the power of the boiler, and incidentally the curved plate to join the larger and smaller parts of the shell, gives a point of expansion which permits the hot tubes to expand, this being taken up in the curve without straining either shell or tube sheets.

4. The figure 95,000 lb. crushing strength means that the material will stand a pressure of 95,000 lb. to the square inch before giving way. A. L. R.

Ice House Specifications

Will you kindly furnish me with brief specifications for building a small ice-house, dimensions to be 10 by 15 by 10 ft.? W. C. S.

A. We assume that for the size you mention, this would be of wooden construction. In that case, the floor would be made up as follows: At the bottom lay ⅞-in. boards, then a layer of insulating paper, and another layer of ⅞-in. boards. These bottom layers of boards should, of course, be raised from the ground in some way, or if the ice house is to be of cheap, temporary construction, the floor may be omitted and a heavy layer of sawdust, say 1½ ft. thick, be used under the lower tier of ice cakes.

If the floor is used, however, on top of the second layer of boards place the floor beams, use 10 by 12-in. beams, spaced 16-in. centers. On these lay ⅞-in. floor, cover with insulating paper, another layer of ⅞-in. boards, then, if specially good construction is desired, put in some 2-in. spacer strips placed over the joists, and put in a second flooring like the first one, of 2 ⅞-in. boardings, with insulating paper between.

For the outer walls, if the walls are to be depended on for insulation, use first a double boarding of ⅞-in. matched boards, with insulating paper between, then the 2-in. spacer strips to give air space, and note that this air spacing should be divided into small sections, by cross strips between the longitudinal spacing strips. Also note that in laying the 2 layers of boarding, joints should be broken both sidewise and endwise. It is better to have the 2 layers run parallel, with the joints in one layer coming over the middle of the boards in another layer, rather than use cross boarding. Beyond the 2-in. air space, use a second double boarding, with insulating paper between, then a second 2-in. air space, and beyond this, a third double boarding. This gives for the walls 3 double boardings and 2 air spaces.

This is a wall intended for the storage of the ice cakes without sawdust packing. If you have in mind the storage of natural ice through the summer, it will probably be stored in sawdust. In that case, a framework of 2 by 6's, 16-in. centers, would be erected, with a

double boarding having insulating paper between, on the inside. Then, in packing the ice, at least a foot of sawdust should be put in between the wall of the ice house and the outer row of ice cakes, at all points, practically 6 in. of sawdust in the bottom, and a covering of 1½ ft. of sawdust over the top layer of ice.

In case the ice is to be stored without sawdust covering, a ceiling should be placed above the ice chamber of the same construction as the floor, in order to prevent the radiation of heat downward from the roof. A. L. R.

Refrigerating Equipment Troubles

WE ARE RUNNING an 80-ton Linde machine, carrying about 25 lb. back pressure and 200 lb. high pressure. At present, we are running on only one tank, and the discharges are at about 240 to 260 deg. F. If we undertake to pull the high pressure down, we lose our load, and of course the machine gets hot. Will you please tell me what is the matter? Are we short of ammonia?

H. H.

A. A back pressure of 25 lb. is too high for ice making as the temperature of the ammonia in the tank coils will be about 13 deg. F., and the brine will be 20 or 22 deg. F.

A discharge temperature of 240 deg. is too high for a Linde compressor when carrying 200 lb. pressure, but should be about 180 to 200 deg. F.

Test both high- and low-pressure gages. I believe the former shows too low and the latter too high.

After the gages are known to be correct, pump the ice tank coils down to a few pounds pressure. Let the water run over the condenser about an hour (with the machine shut down) and then blow out the air or permanent gases.

If you find that the condenser pressure drops fast and below 160 lb., when you stop the machine, it is advisable to put in some ammonia before blowing out the air. Blowing air when the charge is low will result in the loss of ammonia.

You do not mention a gage glass on the liquid ammonia receiver, so I take it for granted that there is none. Put one on at the first opportunity and see that it shows not lower than ½ full when running under ordinary conditions.

As you are running on only one ice tank, it can easily be possible that your ammonia is stored in the coils of the idle tank. Try pumping these coils out.

A. G. SOLOMON.

Burning Shavings

WE HAVE a battery of 3 horizontal return tubular boilers one of which, number 3, is fired with shavings at all times, number 2 with coal and shavings, and number 1 with coal only. When burning these shavings, should the dampers be entirely or only partly closed? When the draft is shut off entirely, the furnace may be kept full of shavings, while, if the dampers are partly open, they must be fired according to the demand for steam.

Will the closed damper cause an excessive amount of heat to be concentrated at some particular spot on the shell plates? We had one boiler badly bagged some time ago, which I judged to be due to operating with a closed damper.

J. D. D.

A. In reply to your inquiry, I submit the following, but wish to qualify it by saying a better reply might be returned had the circumstances of the case been stated more fully.

Although this is not specifically stated, I assume that the bag appeared on boiler 3.

As regards the method of operation and draft regulation, in cases where boilers are fired with a fuel high in volatile matter as with shavings, with dampers closed the heat becomes concentrated because of the stoppage of gas flow, and the unequal temperatures at different points about the settings are not conducive to proper expansive and contractive conditions of the shell plates. A common practice where this kind of fuel is used is to regulate the draft by a stack damper or the flue caps allowing plenty of air under the grate at all times.

J. H. COATES.

Relative Value of Hot Water and Steam Radiation

HOW MUCH space will 1 sq. ft. of radiating surface heat and maintain at 72 deg. F. if the outside temperature is 25 deg. below zero, with a hot water heating system the water of which is kept at 180 deg. F.? How much more radiation is required for hot water heat than steam heat with about 1 or 2 lb. of steam?

H. H.

A. The only thing we can give you in regard to the space heated by a square foot of radiation is an average value. The satisfactory proportioning of radiating surface to space depends on the exposure of the room, the kind of material in the walls, whether there is radiation of heat through the floor and ceiling, and the tightness of the window openings.

The only satisfactory way to get at this is by the method given in the issue of Feb. 15, in the article which accompanies the data sheets. The method of calculation is given in the article and the tables.

Roughly, for dwellings, a square foot of hot water radiation would take care of from 30 to 40 cu. ft. of space. As you want to heat from a very low temperature up to a somewhat unusually high temperature, you would probably need to take the lowest value, and use a square foot of radiation to 30 cu. ft. This should be checked by careful computation in order to make sure of the success.

The relative value of hot water and steam radiation is shown by the corresponding figures for steam. A square foot of steam radiation will take care of from 50 to 70 cu. ft. of space. Under your conditions, it would probably take care of about 50 cu. ft. This is, however, for 5 lb. steam pressure, and if the steam was to be kept at only 1 or 2 lb., you would need to allow more radiation, and it would be safer to assume that a square foot of steam radiation, for a pressure of not over 2 lb., would take care of 35 to 40 cu. ft. Here, again, the whole thing depends on exposure, steam temperature and other conditions, and should be carefully checked by calculation according to the method given in the issue above named. A. L. R.

IT IS THE duty of the employer to furnish reasonably safe tools and equipment; in the eyes of the law nothing but performance will relieve him. It sometimes becomes the duty of the engineer to see that the law is enforced.

Problems For Discussion By Readers

What Would You Do If You Had These Conditions To Meet?

Cleaning Gage Glasses

WILL SOME OF Practical Engineer's readers kindly tell us how to clean water gage glasses?

F. H. J. and J. H. H.

Burning Lignite

ANSWERING THE INQUIRY of W. G. M., in the Nov. 15 issue, I would say that lignite being more bulky than coal and having a much lower heat value, it is essential to have increased grate surface, if the boilers are to work at or above capacity.

Its slowness to kindle, necessitates some system of forced draft, especially after cleaning fires, and where sudden variations in load occur.

Where the fan is belted to shafting and has a constant speed, good regulation of draft may be secured by connecting a damper regulator to a gate in the fan intake. The same results can be secured when the fan is driven by a variable speed motor or engine.

Gates in the discharge, and turbo blowers, have not generally proved satisfactory. Gates, on account of the heat in the ashpit, are liable to go out of commission when most needed.

It is perhaps unnecessary to say lignite requires carrying a thick fire. I fail to see where removing the bridge walls would be of any advantage, unless they were high enough to impede the draft.

The Bureau of Mines some time ago issued Bulletin No. 2 on North Dakota lignite as a Fuel for Power Plant Boilers, which, if not now available for free distribution, may be had from the Superintendent of Documents, Washington, D. C., at a nominal cost.

W. G. M. is up against the same problem we all meet on the lignite proposition.

Why power plant owners and boiler manufacturers will persist in trying to burn lignite in a furnace designed for coal "surpasseth all understanding."

In a plant built 2 yr. ago, they are compelled (?) to use coal, although lignite abounds in that vicinity, a splendid quality being mined less than 3 mi. from the plant. The use of this fuel would cut their cost per unit of manufacture from $0.11 to less than $0.08. Running 200 days a year, this saving would amount to $1800 a yr.

When this plant was designed, half the amount saved per year would have equipped it for the lignite fuel and if no use could be found for the saving, it might have been added to the wages of the engineer and firemen.

Has any reader of Practical Engineer knowledge of a test or tests ever having been made to determine the effect of moisture on economy in boiler furnaces?

MONTANA.

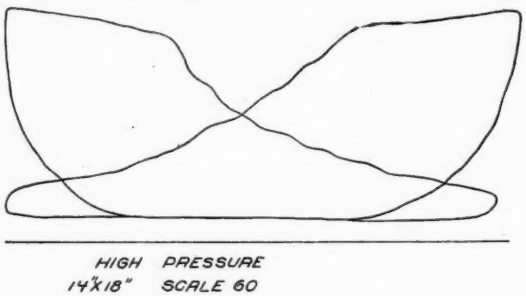
Government Examination Questions

IN REPLY to the request of I. O. M. on p. 976 of the Oct. 15 issue, I submit the following answers and solutions.

1. With a gage pressure of 125 lb. or an absolute pressure of 125 + 15, or 140 lb., a condenser back pressure of 15 — (26 ÷ 2), or 2 lb. absolute and a speed of 250 r.p.m., we are to determine the cylinder dimensions of a 200-hp. compound condensing engine.

Assuming a stroke of 18 in. or 1½ ft. the piston speed is 250 × 1½ × 2, or 750 ft. per min.

We will now proceed to find the diameter of the low-pressure cylinder on the assumption that all of the power is to be developed in that cylinder.



TYPE AND SIZE OF CARDS TAKEN FROM A 14 BY 18-IN. COMPOUND CONDENSING ENGINE

To secure economy, it is necessary to assume a proper high to low-pressure cylinder ratio and cutoff, the former being, let us say, 1 to 2.6 and the latter in the high-pressure cylinder at ⅓ stroke. Under these conditions the total ratio of expansion will be the product of 2.6 × 3, or 7.8.

To find the mean effective pressure, add 1 to the hyperbolic log of the ratio of expansion; multiply by the absolute initial pressure; divide the product thus obtained by the ratio of expansion and from the quotient subtract the back pressure. In this case, the hyperbolic log of 3, or the ratio of expansion in the high-pressure

cylinder, is 1.0986; the absolute initial pressure is 140; the total ratio of expansion is 7.8 and the back pressure, 15 lb. absolute. Substituting these values, we have the mean effective pressure equal to (1+ 1.0986) × 140 ÷ 7.8, or 37.66; this minus 15 is equal to 22.66 lb. as the required mean effective pressure if all the power was to be developed in the low-pressure cylinder.

Horsepower of an engine is equal to p l a n ÷ 33,000 where p in the mean effective pressure in pounds per square inch, l the length of stroke in feet, a the area of the piston in square inches and n the number of strokes per minute. Transposing the above, we have a, or the area of the piston, equal to hp. × 33,000 ÷ p l n which in this case will be 200 times 33,000 divided by the product of 22.66 times 1½ times 500, or 388 sq. in.; extracting the square root of the quotient of 388 ÷ 0.7854, we have 22 + in. as the required diameter of the low-pressure cylinder. Let this be 23 in., so that our low-pressure cylinder dimensions are 23 by 18 in.

Area of the high-pressure cylinder may be found by dividing the area of the low-pressure cylinder by the cylinder ratio, which in this case is 388 ÷ 2.6, or 149.23 sq. in. The diameter of this cylinder is then 13.75 in., or, let us say, 14 in.

One formula for the piston rod diameter is to multiply the square root of the product of the diameter of the piston by the length of the rod, in inches, by the constant 0.145.

In the case of the high-pressure cylinder, we have the piston rod diameter equal to $0.145 \sqrt{14 \times 24}$ or 2.65 or 2 21/32 in. For the low-pressure piston rod we have diameter equal to $0.145 \sqrt{23 \times 26}$ or 3.5 or 3½ in.

On the high-pressure side, the mean-effective pressure is equal to (22.66 ÷ 2) × 2.6, or 29.46 lb. The area of the piston of this cylinder, of 14 in. diameter, is 149.23 sq. in., so that with a mean effective pressure of 29.46 lb. and a piston speed of 750 ft. per min. the horsepower developed is 102 +. In a like manner the horsepower developed in the low-pressure cylinder is 106, which, added to 102 gives us a total horsepower of 208.

RECEIVER.

Economy of Oil Fuel

REFERRING TO C. G. M., page 1062 of the Nov. 15 issue, I offer the following:

The economy of using oil fuel in preference to coal will depend on the locality where it is used, the source of supply and its cost.

In one instance, when I took charge of a small plant where coal was used, the cost per day was on the average of $11 a day of 9 hr. for a 125-hp. return tubular boiler, the coal costing $6 a ton.

In addition, wood refuse from the factory was used. I suggested to the management a change to oil fuel, but it required a deal of argument to make them see my point of view, and when at last I obtained their permission, I set in at once to change it.

The result was surprising to everybody.

The oil was contracted for 1 yr. at 65 cents a barrel and it required about 5 bbl. a day of 9 hr., or a cost of $3.25 a day.

The changes necessary on the boiler in this case were accomplished by removing the bridge wall and covering the grates with fire brick laid loosely on the grates with a space of about 3 sq. ft. left uncovered under the burner, which was inserted between the 2 fire doors by cutting a square hole in the boiler front. The bottom of the combustion chamber was slightly inclined from the grates to the back end of the furnace and the burner placed so that the oil flame would strike this floor about half way between the front and back end of the furnace. Under no circumstances should this flame be allowed to strike the boiler plates direct because of its bad effects on them.

Loose bricks were also placed in the fire door openings so as to fill them completely, the air required for combustion entering through the ash pit doors and up through the uncovered space of grates under the burner.

A 6 by 4 by 6-in. duplex pump was used for pumping the oil from the tank to the burner at a pressure of 60 lb. per sq. in.

The whole cost of installation did not exceed $200 for everything, including labor.

As already said, the economy of using oil fuel will depend on the locality of the source of supply, its first cost and transportation.

Another matter is that of the burner used, its economy in burning the oil and its first cost. An oil burner will cost from $10 to $100, depending on the style of burner.

A burner can easily be made at home for a small cost by using a 1-in. pipe, one end of which is flattened to fan-shape by heating it and then making a slot by a thin hacksaw blade. Inside of this pipe is another ¼-in. pipe which is run to within about 3 or 4 in. of the slot or the tip of the burner.

These pipes are connected to the oil and steam supply by needle valve, the larger pipe to steam and the smaller to oil.

This burner may not be so economical as other burners, but it serves the purpose well, is inexpensive, and is used even in large plants to a great extent.

Fuel oil should be heated to at least 100 deg. F. before entering the burner.

This can be accomplished by an oil heater consisting of a 10-in. pipe closed with flanges or caps about 36 in. long, and inside of the heater is placed a coil of 1-in. pipe through which the oil is circulated, exhaust steam from the oil pump being used for heating.

An oil-burning plant can be installed by the man in charge for a reasonable cost and should give no trouble if properly installed.

In every case where oil fuel has been used to my knowledge, it has proved to give better economy than coal.

I. O. SEFFER.

WATER IN the fuel mixture for gas engines has the attribute of keeping it clear of carbon. No one has been able to tell us just why, but the answer is probably nascent oxygen. In the presence of carbon, water will dissociate into hydrogen and oxygen at a comparatively low temperature. Just at the moment when it is released (nascent), oxygen is very active and will combine readily with carbon in any form.—The Gas Engine.

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Cleaning City Air

Long awaited by the citizens of Chicago, the report of the Chicago Association of Commerce Committee of Investigation on Smoke Abatement and Electrification of Railway Terminals has recently been made public. Monumental and gigantic are terms easily applied to it, for it is a volume 9 by 12 in., of nearly 1200 pages and records, results of over 250,000 observations and tests of smoke making with conclusions drawn besides the rest of 4 yr. work on planning and estimating for electrification. The study of air pollution is the most extensive and scientific ever attempted, and while the conclusions reached are some of them unusual, and some of them discouraging so far as Chicago is concerned, the facts are interesting and worthy of careful study.

Complete electrification, though technically practical, is considered financially impractical at present, as it would result in a net annual deficit (presumably over present conditions) of $14,609,743, a burden too great to be borne by the railroads or the traffic. But partial electrification may begin at any time at the points where it is most needed and most feasible.

So far as air pollution is concerned, the 4 largest agencies are in order, high-pressure steam plants, metallurgical and other industrial furnaces, domestic and apartment house fires, railroad locomotives; hence, the 3 first named require more attention than the railroads, so far as total effect is concerned.

Locomotives, however, discharge their smoke, dust and gases close to the ground, and diffuse it over a wide area, therefore get more universal attention and ill will than the others.

Visible smoke is found to be by no means the only ill, since invisible gases containing sulphur and carrying dust and cinders may do much harm. And these are not due to bituminous coal only, but may come from coke or anthracite coal. Further, only ⅔ of the pollution is due to combustion, the rest coming from street dust, building operations and like causes. And while smoke from solid fuels, whether visible or invisible, is found to be never free from such dust and solid matter, the Committee deems that this shower of soot, dust and cinders, of which some 64 per cent comes from metallurgical and similar furnaces, is more harmful than the visible smoke clouds. High-pressure steam plants rank second as dust producers, making 19.3 per cent of the total amount.

High-pressure steam plants consume some 42 per cent of the total fuel burned in the city and make 44.5 per cent of the visible smoke, and 45 per cent of the invisible gases, hence would seem to be quite as important in a smoke suppression campaign as the activity of smoke commissions in the past have considered them. But low-pressure heating plants, while using only 23.6 per cent of the city's fuel, and making only about 4 per cent of the visible smoke, are responsible for 57 per cent of the sooty materials, such as hydro-carbon, and effort to reduce this is badly needed.

Of the invisible gases, only those containing sulphur are deemed harmful, since they result in the formation of sulphuric acid when in the air. In this connection, crude oil as a fuel is advantageous in reducing harmful

smoke effects, because of its low sulphur content, but there is great possibility of producing sooty elements unless conditions favorable to perfect combustion are maintained.

Comparison of conditions in Chicago with those in other large cities, both in this country and Europe, in spite of the fact that it burns more coal per capita than any other, is favorable, largely on account of the purifying effect of the lake winds which sweep away the gases, and the rainfall which washes the air, but it would hardly seem that these helps are as effective in disposing of the dust and cinders, as in clearing away the gases.

An interesting comment is that direct effects of smoke as ordinarily found in the atmosphere of a smoky city are not shown to be detrimental to persons in normal health, but the physical tone is lowered by long continued breathing of polluted air. Smoke is not shown to increase the progress of tubercular disease nor work against recovery, but has a direct antiseptic action in such cases. On the other hand it is seriously harmful in cases of pneumonia, though these conclusions are reversed by some eminent medical authorities.

Another interesting point is that if electric operation were adopted, in place of part of the smoke from locomotives, that from power plants to furnish the electric current would be produced, so that the net reduction would be only 5 per cent.

As a result of its investigations, which reveal conditions probably not materially different from those in any large city, the Committee recommends the extension of the Smoke Prevention Commission to a Pure Air Commission, of technical experts with adequate funds to determine the most effective means of reducing air pollution not only from combustion of fuel in stationary power plants and locomotives, but also from pavements, alleys, building operations, and domestic fires; such Commission to have power to enforce obedience to its decisions. This means prevention not only of visible clouds of smoke, but cleansing of gases of dust, cinders, sulphurous gases and sooty hydro-carbons, as well as different methods of handling ashes, plaster, street sweepings and other dust producers. In fact, a broad general program of cleaning city air, in which, however, due to their first piace among the agencies of air pollution, high-pressure steam plants will as heretofore be a main consideration.

News Notes

ABERTHAW CONSTRUCTION CO. announces the removal of its offices to more commodious quarters in the newly erected Niles Building, 27 School St., Boston, Mass. Here this company will be still better equipped for handling the construction of industrial plants, dams, and similar structures.

DUQUESNE LIGHT CO. has awarded a contract for 2 turbo generators, with total capacity of 75,000 hp., to be installed in its power house on Brunots Island. One of these generators will have a capacity of 54,000 hp., and will be the largest in the world. The contract has been given to the Westinghouse Machine Co., of Pittsburgh, involving a sale of approximately $1,300,000.

ON DECEMBER 1, the Buffalo Foundry and Machine Co. opened an office in New York City at 1432 Whitehall Building, 17 Battery Place, for the sale of "Buflovak" vacuum apparatus, including vacuum dryers of all types for the drying of all sorts of materials, dry vacuum pumps, condensers, vacuum drying and impregnating apparatus, etc. By opening this office the company plans to give more direct service to its patrons in that territory.

U. S. CIVIL SERVICE COMMISSION announces an examination for marine engine and boiler draftsman on Jan. 5 and 6, 1916, at principal cities, to fill a vacancy in the Industrial department of the U. S. Navy Yard, Portsmouth, N. H., at $3.52 a day, 2 vacancies in the U. S. Navy Yard, Norfolk, Va., one at $3.52 a day and the other at $4.48, and vacancies as they may occur in any U. S. navy yard or naval establishment, or in the Department at Washington, D. C., at entrance salaries ranging from $3.52 to $5.52 a day. Subjects will have the relative weights indicated: Mathematics, 15; materials, details, and specifications, 15; drawing and design, 30; education, training, and experience, 40. Age, 18 yr. or over on the date of the examination. Applicants must submit to the examiner on the day of the examination their photographs, taken within 2 yr. Apply for Form 1312, stating the title, Marine Engine and Boiler Draftsman (Male), to the U. S. Civil Service Commission, Washington, D. C.

U. S. CIVIL SERVICE COMMISSION announces an examination on Jan. 12 and 13, 1916, at principal cities, to fill existing vacancies and vacancies as they may occur in the positions of aid and deck officer in the Coast and Geodetic Survey. Applicants must have reached their 18th, but not their 25th, birthday on the date of the examination. No one will be permitted to take the mental examination who has any defect of sight or other physical defect. Applicants must submit to the examiner on the day of the examination their photographs, taken within 2 yr. Apply for Form 1312, stating the title, Air, Coast and Geodetic Survey (Male), to the U. S. Civil Service Commission, Washington, D. C. Aids are appointed at a salary of $900. The next steps in the line of promotion to salaries of $1000 and $1100 as aid, thence to assistant at $1200, then upward by steps of $200 each. Deck officers are appointed at a salary of $900 for special service on board the ships of the Coast and Geodetic Survey and on hydrographic parties.

U. S. CIVIL SERVICE COMMISSION announces an examination for junior engineer on Jan. 19 and 20, 1916, at principal cities, to fill vacancies in the Water Resources Branch of the Geological Survey. The entrance salaries will range from $1080 to $1200 a year and expenses when on field duty. Persons appointed will be eligible for promotion to the grades of assistant engineer and full engineer after they have demonstrated fitness for such promotion. Salaries of assistant engineers range from $1380 to $2000, and for engineers from $2400 to $3000. Age, 20 yr. or over. Applicants must submit to the examiner their photographs, taken within 2 yr. Apply for Form 1312, stating the title, Junior Engineer (Male), to the U. S. Civil Service Commission, Washington, D. C.

Power Apparatus in Shop and Market

New Ideas In Making, Buying and Selling

Steam Power Air Compressor of New Design

TO provide a steam driven air compressor which will operate satisfactorily with high pressures and superheat as well as at more moderate pressures, a balanced piston steam valve gear has been developed and perfected. This has been incorporated in the design of the standard "Imperial" duplex air compressors, manufactured by the Ingersoll-Rand Co.

The use of a balanced valve makes it possible to control the machine by automatically varying the point of cutoff in the steam cylinders. This method of regulation maintains constant speed by changing steam

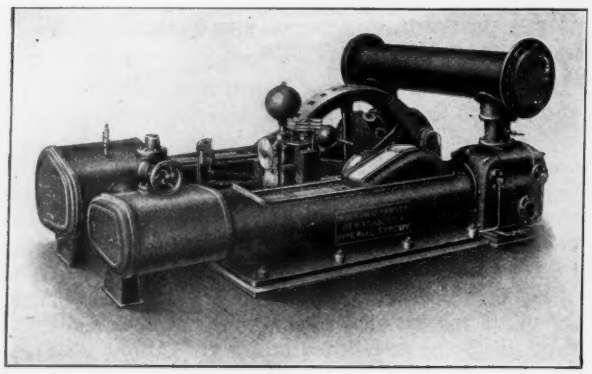


FIG. 1. IMPERIAL TYPE XPV AIR COMPRESSOR

pressures, and, at the same time, varies the speed of operation to the demand for air. Steam is always admitted to the steam cylinder at full boiler pressure and without the wire drawing, which means, in short, that the machine automatically operates at its highest efficiency. It is pointed out that, the higher the steam pressure, the greater the relative increase in efficiency.

This piston valve is a perfectly balanced valve of the telescopic type. The cutoff valves are right and left-hand threaded to a cutoff valve stem. Steam admission is through the center of the valve, the steam then passing through the valve ports to the cylinder and then is exhausted by the ends of the valve. It is to be noted that this construction exposes the valve chest covers and steam packings to exhaust pressure only, proportionately reducing the liability of leakage. The design and even distribution of metal in the Imperial piston valve are claimed to preclude any possibility of warping and to result in a valve so balanced that friction is minimized and lubrication facilitated.

The steam ports are large and unusually direct, and special effort has been made by the manufacturer to reduce the condensation surfaces in the cylinders. Exceptionally complete insulation, the separation of live and exhaust steam passages and the fact that the steam chest partially encircles the cylinder contribute to the steam economy. These points will be readily appreciated from the sectional illustration. The cylinder and receiver lagging is covered with a sheet iron casing and that of the cylinder heads with neatly fitting case covers.

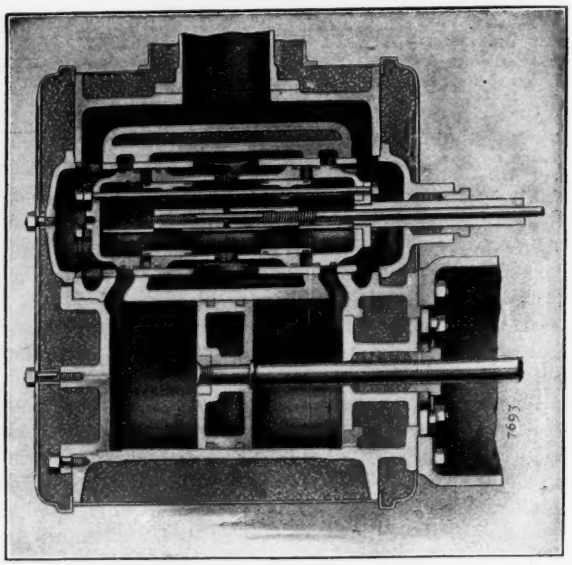


FIG. 2. SECTION THROUGH HIGH-PRESSURE STEAM CYLINDER OF NEW AIR COMPRESSOR

The unique steam receiver is a direct connection between high and low-pressure steam chests. The low-pressure chest is proportioned to furnish additional capacity and so located that the heat ordinarily lost by radiation is used in heating the cylinder and valve. A special expansion joint prevents any possibility of cylinder alinement being destroyed.

The governor is a speed and pressure regulator which varies the cutoff by automatically rotating the cutoff valve stem and changing the relative position of the cutoff valves. It is essentially a chain driven rotary oil pump which acts against a weighted plunger. The variation in oil pressure due to the changing speed of the compressor, or the varying air pressure through the movement of the plunger, changes the cutoff point in the steam cylinders.

This governor is claimed to be entirely automatic in operation and capable of maintaining exceptionally reliable, as well as close regulation.

Lubrication of both air and steam cylinders and valves is provided for by force feed oilers.

The other features of this new compressor, called by the maker "Imperial" Type XPV, are those of the

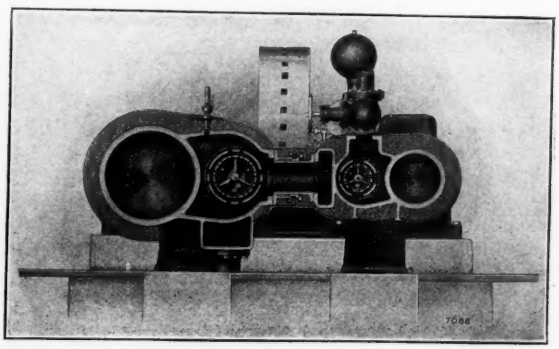


FIG. 3. SECTION SHOWING VALVES AND STEAM RECEIVER

"Imperials" now in service; wholly enclosed main frames containing the reciprocating parts, automatic lubrication by the bath system and the standard Imperial completely water-jacketed air compressing cylinders.

This "Imperial Type XPV compressor is a product of the Ingersoll-Rand Co., 11 Broadway, New York, and is built in capacities from 608 to 3620 cu. ft. per min. and for discharge air pressures from 10 to 110 lb. per sq. in.

Safeguarding Fire Hazards in Old Buildings

IT IS far from our purpose to advocate the continued use of fire traps whether for business, public or private purposes; but common sense would suggest that if certain danger spots were effectively protected so that even if fire started around them, *it could not easily spread,* the hazard would practically disappear so that the old buildings might quite well be continued in use.

Asbestos lumber has a great protective value even against actual flames, while as an insulation for protecting woodwork from the effects of heat, as found in boiler rooms and similar places, it offers almost perfect protection.

A boiler room, ceiled and lined with an asbestos material such as Transite Asbestos lumber, is fire resistant to a high degree. The asbestos lining does not readily transmit heat, as does metal; consequently, the asbestos protected woodwork does not acquire the tinder-like dryness of improperly insulated material; while, in case of actual fire, the flames cannot pass the asbestos lining, nor does the woodwork readily char.

Where partitions are pierced for the passage of flues or pipes, an insulation panel is easily inserted, while a sheet of asbestos wood placed behind a radiator effectively protects the wall.

For electric switchboards, switch boxes, partitions and other installations working at high tension, Ebony Asbestos Wood is entering largely into the equipment of power stations.

By the judicious use of these two materials as indicated, many old buildings may be made reasonably safe without waiting for the order of the fire commissioner. It is far better and usually far cheaper to be prepared, than to wait until the commissioner issues his order.

The owner of a building in which every reasonable precaution has been taken against both the occurrence and spread of any possible fire is in a far stronger moral position than the man who has done nothing.

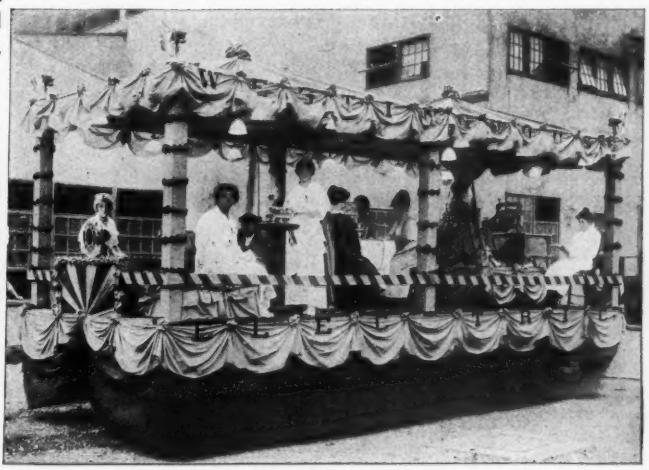
In the one case, he will have done his best, with the result that his efforts are likely to be approved; while, in the other, the building may be condemned without any option.

The Transite and Ebony asbestos woods referred to herein are the products of the H. W. Johns-Manville Co., of New York.

A Prize Winning Float

ADVANTAGES of the use of electricity in the modern household were attractively and convincingly displayed in the float shown in the accompanying illustration, which was entered by the Westinghouse Electric & Mfg. Co., in the parade held during the recent celebration by Wilmerding, Pennsylvania, of its 25th Anniversary.

Owing to the fact that the parade was held at night, the electric float was the center of attraction, the profuse illumination afforded by the 14 60-w. lamps placed



FLOAT USED TO DEMONSTRATE THE ADVANTAGES OF ELECTRICAL HOUSEHOLD APPLIANCES

around the sides and 2 100-w. lamps hung from the center, adding greatly to its attractiveness.

The float represented 2 scenes, the front one being that of a dining room in which an electrically prepared dinner was being served to a number of young ladies. By means of table stoves, coffee percolators and other devices, dinner was prepared right at the table. Two of the young ladies stood up and popped corn over an electric stove and threw it out among the spectators, all the way along the route of the parade.

In the rear portion was shown a laundry scene, emphasizing the difference between the "old" and the "new" way of washing. On one side was an electric

washing machine busily washing the clothes while the young lady in her good clothes was sitting comfortably by, reading a book, giving the machine only an occasional glance. On the opposite side was an old negro "mammy" bending over an old-fashioned back-breaking washtub.

In this part of the float was also a table on which were placed a number of different electrical labor saving devices. A Cozy Glow radiator, the soft light from which added much to the attractiveness of the scene, was also included.

An electric vacuum cleaner set opposite an old-fashioned long handled broom served further to emphasize the advance in household efficiency.

Current for the operation of lights and other devices was obtained from a 300-amp.-hr. storage battery placed under the flooring.

Air Pressure for Automobile Tires

CARE of the trucks and business cars of an establishment frequently falls to the lot of the power department, and an important item in upkeep expense is tire replacement. Some $192,000,000 a year is the cost of tires in this country and statistics which have just been compiled by the experiment department of the Goodyear Tire & Rubber Co. show that 30 per cent of this enormous sum is being squandered by ill-advised loading of tires. In other words, $57,600,000 will be wasted this year through failure to observe proper precaution in the matter of loading tires.

P. W. Litchfield, factory manager of the Goodyear Co., in his paper presented before the Society of Automobile Engineers at the summer conference, suggested a remedy for this waste by the adoption of a sliding scale of carrying capacities and inflation pressures. This is essentially the adaption of the air pressure to the load imposed on the tires.

GROSS LOAD, POUNDS PER TIRE, INCLUDING PASSENGERS AND COMPLETE EQUIPMENT

Inflation Pressure, Lbs.	Tire Section Diameter						
	3 in.	3½ in.	4 in.	4½ in.	5 in.	5½ in.	6 in.
30	250						
35	290	360					
40	335	410	500				
45	375	460	560	675			
50	415	515	625	750	875	1000	1140
55	460	565	690	825	960	1100	1255
60	500	615	750	900	1050	1200	1370
65		670	815	975	1135	1300	1480
70		720	875	1050	1225	1400	1595
75			940	1125	1310	1500	1710
80			1000	1200	1400	1600	1925
85				1275	1485	1700	1940
90				1350	1570	1800	2050
95					1660	1900	2165
100						2000	2280

"Long experience has shown that these loads and air pressures are the most satisfactory combination for maximum service and effective cushioning," says Mr. Litchfield. "The quantities of comfort and easy riding must be recognized as vital points, equally as important as tire durability. Why are pneumatic tires used at all if not for easy riding qualities?

"The degree to which a tire is flattened against the ground varies with the load. For every given tire load there is a definite percentage of tire deflection which bears a direct relation to the inflation pressure. Obviously, then, a scale of relative carrying capacities and inflation pressures, if properly observed, will tend to eliminate the enormous waste now caused by haphazard methods of loading and inflating.

"The load properly assigned to a tire should be the actual load on the tire with the car fully loaded. The actual load on each tire can be ascertained by weighing first the front of the fully loaded car, then the rear, dividing each figure by 2 to get the load per tire. It can then be inflated to the proper pressure for that particular weight as indicated by the scale of carrying capacities and inflation pressure. A certain tolerance in pressure should be allowed for leakage, but before the pressure drops 20 per cent the tire should be pumped up again.

"Realizing, of course, that every consumer has a right to his own ideas as to what constitutes good service, and that no practical inflation schedule will cover all possible conditions of service, the accompanying schedule is offered and recommended as a guide under normal conditions.

"ELECTRICAL PROSPERITY WEEK received the endorsement and support of Governors of States, Mayors of Cities, Chambers of Commerce, Boards of Trade and other industrial organizations throughout the country," writes J. M. Wakeman, Gen. Mgr. The Society for Electrical Development. "I think the climax was reached, however, when I received the following letter from the president of the United States, and I believe it will interest your readers":

The White House,
Washington. Nov. 23, 1915.

My Dear Sir:

I am glad to learn from your favor of the 11th instant that the Society for Electrical Development will celebrate Electrical Prosperity Week from Nov. 29 to Dec. 4, and to be advised that the object of this celebration is to create in the public mind a firm confidence in the business institutions of America.

There can be few things of greater importance to the people of the United States than that they should have strong confidence in themselves and in the institutions and industries which they have created. I earnestly commend the effort on your part to develop and maintain reliance by our people in their own ability to meet the problems of industrial and national life. Such a reliance may be wisely based on what we have achieved heretofore. With such a reliance we may look fearlessly to the future.

Sincerely yours,
(Signed) WOODROW WILSON.

LARGE SQUIRREL CAGE induction motors, type CS, are fully described and illustrated in Leaflet 3787, recently issued by the Westinghouse Electric & Mfg. Co. These motors have been especially designed for heavy duty, constant speed, continuous service. The construction is shown in some detail in the leaflet.

Book Reviews

STEAM BOILER ECONOMY, second edition, revised and enlarged, by William Kent, 717 pages, illustrated; New York, 1915.

In this work, the author revises the first edition which was printed some 14 yr. ago, bringing the book up to date in every respect, describing the various improvements which have been made in boiler room equipment and practice. Since the publication of the first edition, steam pressures have increased, construction and care of boilers have improved, the smoke nuisance has decreased, boiler efficiencies have increased, boilers are run at a higher rate, and many other elements have contributed to improvement in modern practice.

In the beginning chapter, the author takes up Principles and Definitions, following this with 5 chapters on fuels, taking up combustion, formation of coal, coal fields, coal analysis, the heating values of various American and foreign coals, and other related subjects. Following this section is a chapter on Furnaces, Methods of Firing, Smoke Prevention, Mechanical Stokers and Forced Draft. Chapter 8 is devoted to Elementary Principles of Boiler Economy and Capacity; Chapter 9 to Efficiency of the Heating Surface. Types of Steam Boilers are discussed in Chapter 10, and in Chapter 11, the Horsepower of the Steam Boiler, proportions of Heating and Grate Surface, and the Performance of Boilers are made the subjects of discussion. Chapter 12 takes up Points of a Good Boiler; Chapter 13, Boiler Design and Construction; Chapter 14, Boiler Attachments and Boiler Room Appliances; Chapter 15, Boiler Troubles and Boiler Users' Complaints. The remaining 4 chapters are given up to Evaporation Tests and Boiler Room Trials, Properties of Water and Steam, and miscellaneous subjects.

The book throughout is handled in a masterly way, and contains many tables and charts valuable to those who have boilers to design or operate, and is one of the most valuable recent additions to engineering literature.

THE GASOLINE AUTOMOBILE, by G. W. Hobbs and B. G. Elliott; November, 1915; 6 by 9 in., 260 pages, fully illustrated and indexed; in cloth binding, price $2.

Admirably well done, and embodying just the information which most people want in regard to automobiles, is this book, which was prepared in the Extension Division of the University of Wisconsin by the authors, one of whom is an instructor in this extension work, and the other, associate professor in the University of Nebraska. The book does not bear, however, the earmarks of what is sometimes considered "professional style." As the authors state in the preface, the purpose of the book is to give the driver a complete understanding of the principles underlying the operation of his car, and enable him to secure better service at less expense, and increase the pleasure of owning and driving his automobile. The book has been written by men who not only understand the principles and the mechanism of the automobile, but know where the emphasis needs to be placed in order to make the machine familiar to its owner. There is no long dissertation on the action of a 4-cycle gas engine, although the principles of such are explained, but there is careful explanation of the mechanism of valve timing and setting, of the arrangements of the poppet type and the Knight type, and the other mechanical details which an automobile owner wants to know in order to handle his machine understandingly and make such minor repairs as are usually wise for him to undertake.

The book is up-to-date in every particular, and gives the latest practice in 8 and 12-cylinder engines, as well as in the details of transmissions, differentials and rear axle construction.

The chapter headings will give an idea of the completeness of the book, and a careful reading has proved that it is an ideal volume for the man who drives, or the man who is engaged in selling or repairing cars. The chapter headings are: 1, General Construction; 2, Engines; 3, Power Plant and Transmission Systems; 4, Fuels and Carbureting Systems; 5, Lubrication and Cooling; 6, Batteries and Ignition; 7, Magnetos and Ignition; 8, Starting and Lighting Systems; 9, Troubles and Remedies; 10, Operation and Care.

Catalog Notes

ESTABLISHING AND MAINTAINING Boiler Room Economy is the title of a paper presented before the Ohio Society of Mechanical, Electrical and Steam Engineers by Geo. H. Gibson, developing the thesis that the most important requisites to further improvements of boiler plant economy are means of recording boiler performance—that is, of determining the number of pounds of water evaporated per pound of coal. This pamphlet is being distributed by the Harrison Safety Boiler Works, Philadelphia, Pa., manufacturers of the Cochrane Open Feed Water Heater, from whom copies may be obtained.

STREET SERIES Mazda lamps, designed for operation on circuits regulated for current, are the subject of Bulletin 11C of the Engineering Department, National Lamp Works of General Electric Co.

The Cleveland lantern for ornamental lighting, adopted by Cleveland, O., for its downtown district, is described in a folder from the company.

BULLETIN NO. 98, on Foxboro Improved Recording Gauges for all purposes, illustrates and describes several new improvements, also illustrating typical records from the recorders in actual service, and showing halftones of interesting installations. The manufacturer is the Foxboro Co., Foxboro, Mass.

DATA ON THE use of Insuluminum is contained in a pamphlet prepared by the Diamond Power Specialty Co., of Detroit, Mich., and which can be had on request, showing its heat-resisting properties and its record in use in soot-blower units.

A PAMPHLET, entitled "The Westinghouse Christmas Campaign," illustrates electrical household devices and tells when the Christmas advertising of these will be published in various periodicals.

A FOLDER relating to a book which deals with the subject of air washing was lately received from American Blower Co., of Detroit, Mich.

SMALL MOTORS No. 24 gives brief descriptions of a complete line of small motors offered by Westinghouse Elec. & Mfg. Co., illustrating one of each kind.

CROUSE-HINDS motor starting switch condulets are described and the different types and sizes are listed in Bulletin No. 1000D, supplement to Condulet Catalog No. 1000 of Crouse-Hinds Co., Syracuse, N. Y.

RECORDING LIQUID level gages manufactured by the Bristol Co., Waterbury, Conn., are illustrated in the company's latest circular, which also gives specimen records obtained with the gages.

GENERAL CATALOG No. 52, recently received from Edge Moor Iron Co., Edge Moor, Del., contains a description of the Edge Moor water-tube boiler, and some interesting engineering data.

SWING CHECK VALVES, which can be used in either horizontal or vertical position, are among the types of valves illustrated in a folder lately received from the Ohio Brass Co., Mansfield, O.

MINE SUSPENSIONS AND CLAMPS is the title of a descriptive leaflet, No. 3859, just issued by the Westinghouse Electric & Mfg. Co., describing and illustrating a number of trolley fittings adapted for mine work.

Motor-generator sets are described in leaflet No. 3742-A from the same company. Motor-generator sets from 2 to 200 kw. capacity, consisting of squirrel cage induction motors and direct current generators are thoroughly described therein.

COOLING PONDS for Condensing Engines is the subject of a pamphlet giving the contents of a paper read before the National Association of Cotton Manufacturers at their 99th meeting, Sept. 11, 1915.

Sprays for Cooling Condensing Water, Bulletin No. 101 from the same company, Spray Engineering Co., 93 Federal St., Boston, Mass., contains a general description of spray cooling ponds, discussion of power requirements, cooling capacity, economy, spray nozzles, etc., and illustrates some installations.

BUREAU OF MINES publications are ready as follows, a limited supply being available for free distribution:

Technical Paper 64, determination of nitrogen in coal, a comparison of various modifications of the Kjeldahl method with the Dumas method, by Arno C. Fieldner and Carl A. Taylor, 1915, 25 pp.; Technical Paper 105, pulmonary disease among miners in the Joplin district, Missouri, and its relation to rock dust in the mines, a preliminary report, by A. J. Lanza and Edwin Higgins, 1915, 49 pp.; Technical Paper 112, explosibility of acetylene, by George A. Burrell and G. G. Oberfell, 1915, 15 pp.; Technical Paper 116, miners' wash and change houses, by Joseph H. White, 1915, 27 pp.; Technical Paper 123, notes on the uses of low-grade fuel in Europe, by R. H. Fernald, 1915, 37 pp.

Requests for all papers cannot be granted. Order publications by number and title, addressing applications to the Director of the Bureau of Mines, Washington, D. C.

PRACTICAL ENGINEER

Trade-mark, Reg. U. S. Pat. Off.

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POSITION WANTED—As Meter Foreman and Power Salesman. Have had nine years' practical and technical experience. Thoroughly familiar with the requirements of the Public Service Commission of Pennsylvania. Address Practical Engineer, Box 405, Chicago, Ill. 11-1-3

POSITION WANTED—Steam engineer wants position in water works or mill plant; 33 yr. old. Married. Sober. Best of references. Iowa preferred. Address F. J. Kirkpatrick, Indianola, Iowa. 12-15-1

POSITION WANTED—By engineer, age 37, married, where reliability, capability, efficiency and economy would be appreciated. Prefer Chicago or vicinity. Address Practical Engineer, Box 411, Chicago, Ill. 12-15-1

POSITION WANTED—By engineer, 8 yr. experience with steam and electric. Understand gas engines and refrigeration. Temperate, reliable, married man. Member N. A. S. E. Address W. H. Snyder, 53 Brown St., Hartford, Conn. 12-15-1

POSITION WANTED—Stationary Operating Engineer, age 27 years, quick learning and a hustler, wants position with a Mechanical or Electrical Engineer or Concern, with chance for advancement. Address Practical Engineer, Box 407, Chicago, Ill. 12-1-2

POSITION WANTED—Chief Electrician. Young man having had long experience in installing, maintaining and repairing in A.C. and D.C. plants, desires to take charge where improvements in motor operation will be welcomed. Address Practical Engineer, Box 409, Chicago, Ill. 11-1-14

POSITION WANTED—As advance sales prospect man with firm manufacturing or selling power plant machinery, by thoroughly practical engineer with several years' traveling experience. Can furnish my own auto if desired. Address Practical Engineer, Box 412, Chicago, Ill. 12-15-1

POSITION WANTED—As operating engineer; perfectly at home in either electric lighting or ice plants; 15 years' continuous experience. Married, sober and reliable man. Address E. S. C., care Practical Engineer, Chicago, Ill. 11-15-3

POSITION WANTED—By man 26 years of age. Have had 28 months' experience as general man around stationary power plant, and 2 yrs. running traction engine; also hold fireman's license. Reference will be furnished to any one wishing to correspond with me concerning position. Address Geo. M. Bucey, 1614 O St., Lincoln, Neb. 11-1-4

POSITION WANTED—As superintendent of an electric light or power plant. I want a chance to demonstrate my ability in any department or branch of this work. Willing to go anywhere, in any kind of a power plant. Married; 42 years old. Good habits. Can furnish references. Address I. W. James, Nappanee, Ind. 12-15-1

POSITION WANTED—Chief engineer, now employed, wants change. With present company 10 years. Understands ammonia refrigeration, air compressors, pumps, etc. All electrical repairs—A.C. and D.C., phone wiring, etc. 72 per cent boiler efficiency last year. 35 years old. American. What have you to offer. Address Box 415, Practical Engineer, Chicago, Ill. 12-15-1

POSITION WANTED—By a young man, experienced operating engineer in both steam and electricity, as manager of light plant in a town of from 2,000 to 5,000. Can show a good record as an organizer. Full qualifications and references upon request. Address Box 374H. Practical Engineer, Chicago, Ill. 12-15-1

DON'T LOSE YOUR RIGHTS to patent protection. Before proceeding further send for our blank form Evidence of Conception to be signed and witnessed. Book, suggestions and advice free. Lancaster and Allwine, 292 Ouray Bldg., Washington, D. C. 12-15-1

POSITION WANTED—Manager, experienced in brass sheet, tube, wire and stamped and screw machine products manufacture, ready for prompt engagement. Technical and sales ability. Full references available to proper parties. Age 31. Address Yankee, care Practical Engineer, Chicago, Ill. 12-15-1

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FREE ENGINEER BOOKS and power plant tool and specialties for securing new subscribers to Practical Engineer. A dandy chance for the engineer with a little spare time to get some fine premiums. Send for free descriptive circular and terms. Address Practical Engineer, Subscription Department, Chicago, Ill.

WANTED—Resident subscription agents in the following cities: Atlanta, Ga.; Cincinnati and Columbus, Ohio; Kansas City, Mo.; Los Angeles, Calif.; Louisville, Ky.; Newark, N. J.; New Orleans, La.; Portland, Ore.; St. Louis, Mo.; San Francisco, Calif.; Washington, D. C. This is an excellent chance for a hustler, who is familiar with power plant conditions, to turn his spare time into dollars. To such a one we offer a Real Opportunity. Write Subscription Department, Practical Engineer, 537 S. Dearborn St., Chicago, Ill. tf.

Wanted

WANTED—Agents handling engine and boiler-room specialties in every section for side line paying large commissions. Give experience, line carried, and territory covered. Address Practical Engineer, Box 381, Chicago, Ill. tf.

WANTED—Agents on commission to sell our Shaking Grates. We will install grates on trial or put in on test at our expense with any grate made. Address Armstrong Mfg. Company, Springfield, Ohio. tf.

For Sale

BOILERS: (two 250 H.P. Heine water-tube boilers, 150 lb., $950 each; (four) 300 H.P. Sterling water-tube boilers, 150 lb., $1100 each; (one) 500 H.P. Sterling water-tube boiler, 200 lb., $1750. 110 volt lighting dynamos, General Electric make; 30 Kw., $200; 25 Kw., $175; 20 kw., $160; 14 Kw., $140; 9 Kw., $100. Duzets & Son, 50 Church St., New York, N. Y. tf.

Patents and Patent Attorneys

PATENTS—C. L. Parker, Attorney-at-Law and Solicitor of Patents. Patents secured promptly and with special regard to the legal protection of the invention. Handbook for inventors sent upon request. 186 McGill Bldg., Washington, D. C.

PATENTS—H. W. T. Jenner, Patent Attorney and Mechanical Expert, 606 F St., Washington, D. C. Established 1883. I make a free examination and report if a patent can be had, and the exact costs. Send for full information. tf.

A. P. CONNOR, Consulting Electrical and Mechanical Engineer. Attorney-at-Law and Solicitor of Patents and Trade-Marks. Results guaranteed. 121 Carroll St., S. E., Washington, D. C. tf.-x

PATENTS THAT PROTECT AND PAY—Advice and books free. Highest references. Best results. Promptness assured. Send sketch or model for search. WATSON E. COLEMAN, Patent Lawyer, 624 F St., N. W., Washington, D. C. tf.

PATENTS—Send sketch for free search and reports. Books on patents and book of reference letters sent free. John S. Duffie & Co., 612 F St., Washington, D. C. tf.

PATENTABLE IDEAS WANTED—Send for three free books. R. B. Owen, 28 Owen Bldg., Washington, D. C. tf.

Education and Instruction

ENGINEERS' POCKET MANUAL; 175 pages; gilt edges; bound in leather; edited by University of Tennessee; will be mailed every subscriber sending in one NEW subscription (not your own) to Practical Engineer.

Miscellaneous

ENGINEERS, DO YOU WANT to utilize your exhaust steam for heating or drying purposes, without back pressure on your engine? If so, address Monash Engineering Co., 1413 W. Jackson Blvd., Chicago, Ill.

Inventions

INVENTIONS commercialized on cash and royalty basis. Inventors and manufacturers should write Adam Fisher Mfg. Co., 2175 Railway Exchange, St. Louis, Mo. tf.

Sparks From The Advertising Pages

"Peace on Earth"

Two-thousand years ago the Christmas message, "Peace on Earth Good Will Toward Men" rang out on the Syrian sky. Those words were destined to redound through the ages. They can never die for in them is the philosophy of the universal brotherhood of man.

Sung at a time when peace was a nonentity, they come down to us again as a message of peace in a world at war. Is there any room for this sentiment? Can we stop our ears to the thunder of guns and hear the greater message that hails us as humans and not as beasts? Can we overlook the five millions of dead and the still greater number of maimed —the desolate villages—the devastated nations —for it is into such a world that is flung this word of peace? No, we must not assume a stolid and calloused indifference to all this though we may continue to maintain an attitude of neutrality.

Even today faint whispers of peace can be heard and who knows but that on the morrow some miraculous means may conciliate the nations even as the first Christmas message closed the temple of Janus, as tradition says, and caused the emperor to proclaim peace for the first time in any Roman dynasty.

But of this there is a certainty—channels of public discussion about the actual aims of the belligerents must be thrown open and nations and monarchs must disclose their true purposes.

Imagine if you can, the result if the governments were to communicate all the facts to the public, if their constituencies knew that their beloved country was plunging headlong into bankruptcy and commercial ruin. It does not take a wide stretch of the imagination to picture these people, even those who loyally stand their ground at the battle front, rising up in such vigorous protest as to force the governments to bring about an amicable settlement at once.

As it is, the men effected most are mere puppets in the hands of their rulers—are being moved about in checker board fashion by minds that refuse to state their actual aims.

Diplomats are not of much avail during such a crisis, but the right kind of publicity —the whole truth and nothing but the truth —would gainsay any ruler or combinations of rulers.

Even if the war goes on indefinitely, this method will be used, at least as a vital contributary cause to a final and satisfactory termination. The tragedy is that it is not used now—and the sword sheathed and turned into plow-shares and harmony once again restored.

Only by this method of publicity can the situation be made clearer, the olive-branch offered, and the Christmas message given its right interpretation, "Peace on Earth to Men of Good Will."